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8 April 1963

THE LIBRARY AND INFORMATION NETWORKS OF THE FUTURE

Prepared by

THE AMERICAN LIBRARY ASSOCIATION

50 East Huron St.

Chicago 11, Ill.

Contract No. AF30(602)-2578

Prepared for

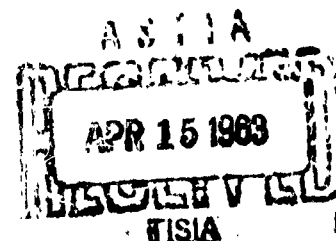
Rome Air Development Center

Air Force Systems Command

United States Air Force

Griffiss Air Force Base

New York



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Errata sheet to be attached to inside of front cover of RADC TDR⁶² 614 entitled "The Library and Information Networks of the Future."

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* * *

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RA/DC-TDR-62-614

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FOREWORD

The purpose of this study is to explore for the Air Force the impact which advances in technology are apt to have on information systems, and to conceptualize the nature of future electronic libraries and information centers which will operate as part of vast regional information networks.

Since Vannevar Bush first articulated the information problem in 1945,¹ there has been a steady increase in the notion that, because of improvements in communication technology, we may someday witness important changes in the way man records and utilizes information. Information is the basic ingredient of decision-making. As the world grows more complex the situations for decision-making are intensified, and the need for highly efficient information systems correspondingly increases. This theme is as true in the Air Force—faced with the operation of large-scale command and control information systems—as it is in industry, where the thrust is toward optimizing the rate of technological progress by avoiding duplication of research and capitalizing on the findings of others.

An intense interest in the information problem has been shown by the highest level policy makers in the United States Government, and today the awareness that information is a vital national resource is an accepted and established fact. The notion of a national information network is not new. Julius N. Cahn, Director, Scientific Research Project, Senate Committee on Government Operations, in a talk given at American University in 1962,² stated the national interest as follows:

A system of information systems is required because information is a national resource. The resource can be maximized only if it can be made more than a jumble of fragments. Information must be assembled for the good of the Republic . . .

He went on to provide a picture of a national information network in the following terms:

As a substitute for the concept of a "system of systems," some observers have suggested different analogies. Some have used the concept of an "Information Network." It would consist of a series of "stations," each of which would serve a particular audience, but which would transmit over the equivalent of "coaxial lines" or "microwave," the best of centrally prepared material as well.

Still other observers have used the concept of a "central information switchboard," such as serves independent telephone companies, or a "grid" such as electric utilities provide, "feeding" power from one location to another at times of peak loads.

Whatever the analogy, an urge for "togetherness" can be observed, a will to explore the possibility of common answers to common problems.

¹ Vannevar Bush, "As We May Think," *Atlantic Monthly*, LXXVI (August 1945), 101-108.

² Julius N. Cahn, "A System of Systems." Paper presented at the Fourth American University Institute for Information Retrieval, Washington, D.C., February 12, 1962.

The original contract awarded to the American Library Association (ALA) by the Rome Air Development Center called for the logical development of a highly visionary concept of the electronic information center as it would appear in 2000 A.D. The vision could be extended to a world-wide network of optical speed computers transmitting instantaneous information in any form and in any language to any requesting user of the system. Having received this contract from the Air Force, the ALA attempted to develop the rules which will govern the eventual behavior and appearance of such a system. This preparatory work, as well as early technological investigations, indicated that the dynamic pace of present-day scientific and engineering accomplishments would permit the foundations of the concept to be laid today. Many of the aspects, including all of the fundamentals, of the over-all concept are available now, or will be operational within the next five to ten years rather than in 100 years as was first imagined. Therefore, the contract requirement was modified to encourage the ALA to think in terms of actual systems for the near future.

The concept, which can be described and implemented today, is a national network of regional and local electronic information centers. The future domain of such a system will extend beyond international boundaries along guidelines compatible with those established for the present-day system. In effect, we will describe the basic character of the information network, with allowances left for added depth of information-handling and the increased expanse of communication.

INFLUENCE OF LIBRARY-21

Most of the notions contained in this report were inspired by exhibit planning for the American Library Association's LIBRARY-21 at the Seattle World's Fair. (See Section I.) This led Association members to the conclusion that the profession would benefit greatly by undertaking an additional study directed toward better understanding of the probable implications and character of tomorrow's information facilities. In doing this study, the ALA's objective was to focus attention on the cultural and national importance of making the fullest use of recorded knowledge and historical accomplishment.

This report reflects the experience and combined views of the LIBRARY-21 research-project staff, as well as the professional opinions of the LIBRARY-21 Advisory Committee whose membership was drawn from both the library and data-processing professions. It describes the implications of applying all facets of new technology to library functions and forecasts an entirely different system of information communication in the future. It takes into account the full range and potential of modern technology—communications, electronic files, mechanical translation, data handling techniques, programmed learning devices, etc.

LIBRARY-21 was first envisioned in a feasibility study prepared by Joseph Becker for the ALA under a grant from the Council on Library Resources (CLR). The Council, created by the Ford Foundation, is the principal agent which furthers research and investigation in the areas of information retrieval and library technology. Many of the ideas in this report reflect the results of CLR research programs. The ALA wishes to acknowledge the Council's important role in the creation of LIBRARY-21 and in accelerating technological interest in the library world.

The American Library Association also is grateful to the U.S. Air Force for making it possible to study an important professional area and to publish its findings. We believe the report represents another step forward in the search for more fruitful ways and means to strengthen and improve our national information resources. Since the problems of storing and retrieving information are interdisciplinary, we believe the study will be of value to librarians, educators, engineers, data-processing manufacturers, documentalists, and to those in the U.S. Air Force who are engaged in handling information. We further hope that our conceptualization of the electronic information network in tomorrow's complex society will assist all to gain a clearer picture of long-range goals, thus enabling them to accelerate toward common objectives.

ACKNOWLEDGEMENTS

The American Library Association has utilized the personal services of the staff which worked on the LIBRARY-21 exhibit to perform this study and prepare the report for the U.S. Air Force. In the process, it also drew on the consulting resources of an Advisory Committee composed of the following distinguished librarians, documentalists, and data-processing personnel:

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ABSTRACT

This report describes the environmental framework for an electronic information of the future and forecasts a network system of information communication. It is based in part on the experiences gained by the American Library Association in planning its LIBRARY-21 exhibit at the Seattle World's Fair.

The report is organized into three main sections. The first describes the structure and organization of ALA's electronic library of the future (LIBRARY-21) and includes a summary of the ideas which went into its planning. The second introduces the concept of regional information networks and explains the requirement for such networks and the likely effects of technology on their development. This section also attempts to provide a realistic suggestion for implementing regional information networks; for purposes of illustration, it describes in some detail how Air Force contractor reports would be treated within such a design. Section III is a compendium of various applicable systems and equipment which are either available for use today or can be expected as part of tomorrow's technological development.

Emphasis is given throughout the report to the critical needs of government, industry, and research groups for improved information systems. Attention is also focused on the personal needs of the individual user.

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I. INTRODUCTION

PHYSICAL DESCRIPTION OF LIBRARY-21

During the period 1960-62, the American Library Association planned and installed an exhibit, known as LIBRARY-21, at the 1962 Seattle World's Fair. LIBRARY-21 was co-sponsored by the ALA and members of the data-processing and publishing industries. It was the first integrated presentation of electronic equipment and scientific techniques within a public library setting. LIBRARY-21 was opened to the public on April 21 and remained on display until October 21, 1962. The exhibit was visited by 1,800,000 people.

Essentially, the purpose of LIBRARY-21 was to provide the public with an entirely new and dynamic educational experience. Various forms of mechanization and electronics conveyed to visitors that the newer educational media, such as film, microforms, television, and various audio devices are related to communication received through the printed pages of a book, periodical, document, or ephemeral near-print source. The exhibit contained the latest forms of library service and design, with particular emphasis on data processing, information storage and retrieval, and advanced means of communicating information in graphic or recorded form.

LIBRARY-21 demonstrated typical library resources and services, with particular emphasis on personal service to the individual. It stressed the value of interlibrary communication and cooperation and attempted in a sensible and realistic manner to integrate machines into an environment of books. It demonstrated new equipment, imaginative ideas, and advanced library programs of service to the general public. It presented the library as the community's nerve center that provides an active situation for self-education, recreation, and

research. It demonstrated new technology adaptable to library processes, making clear that the importance of research and development program in business, industry, and government must not be overlooked in the concept of the new library service.

The LIBRARY-21 exhibit occupied some 9,000 square feet of ground space in the southeast corner of the Washington State Coliseum at the Seattle World's Fair. The usable exhibit area was approximately 6,000 square feet, surrounded by shallow pools of water. The entire exhibit was designed by Vance Jonson of Los Angeles; the architectural firm was Daniel, Mann, Johnson, and Mendenhall, also of Los Angeles.

The physical exhibit was designed to provide an educational experience for the general public and staff, an experience in which the Fair visitor might participate either actively or vicariously. Two circular exhibit areas, each 60 feet in diameter and each surrounded by plexiglass or wood walls six feet high, were connected by a linear walkway. The pools around the exhibit symbolized man's exodus from one continent to another. A concrete walkway, 42 feet long, provided the approach to the exhibit's main entrance.

Alongside the entrance walkway, a symbolic display of the development of communications was presented in a series of transparent plastic spheres arranged in geometrically increasing numbers. Sponsored by the International Business Machines Company, this exhibit began with the most primitive means of communication, the human mouth and ear, and ended with the present-day IBM punched card used in computers. A professional librarian was stationed at the entrance to welcome visitors to

LIBRARY-21 and to explain its various parts.

The center and left side of the first circular exhibit area was occupied by a Solid State 90 Computer, supplied by the Univac Division, Sperry Rand Corporation. The central carpeted area provided space for a high-speed printer and desks where visitors could ask for information from the computer. The outer platform area housed the remaining units of the computer.

The computer display was deliberately simplified for the general public. A committee of the Adult Services Division, ALA, in cooperation with the Univac Division of the Sperry Rand Corporation, prepared three kinds of information for storage in the computer: "personalized" biographies created from a store of 8,400 book titles; quotations from 74 authors whose work appears in the *Great Books of the Western World* series; and gazetteer information on 92 nations of the free world, supplied by the U.S. Department of Commerce.

Visitors desiring personalized bibliographies supplied the computer with information about themselves and indicated subjects in which they were interested. The subjects available for selection by the questioner were: International Relations, The Current Scene in America, The Past Recaptured, The Arts, Space Science, and Mental Health. The machine was able to provide short annotated bibliographies on these subjects, keyed to the following variables as they characterized the questioners: Age—1-8 years, 9-12 years, 13-19 years, and adult; Male or Female; Purpose—information or recreation; Readability—elementary, medium, and advanced; and Education—high school or college.

Even more exciting, the computer provided visitors with an opportunity to "converse" with the great minds of the Western world. By programming the computer with portions of *Great Books of the Western World* series under the direction of Mortimer Adler, it was possible to receive printed quotations from Plato, Chaucer, St. Thomas Aquinas, Cervantes, Milton, John Stuart Mill, Kant, and Henry James, to mention only some of the 74 authors. Some of the subjects stored for conversations and selected for inclusion by means of the Syntopicon were Man, Family, Punishment, and God. The computer also offered a quantity of gazetteer-type data, prepared in cooperation with the U.S. Department of Commerce. Up-to-the-min-

ute facts on 92 nations, ranging from members of the European economic community to the newly emerged African nations, were available. The categories included: resources, population, area, language, imports, exports, etc.

A professional librarian was on duty in this area to explain the use of computers in library information storage and technical processes.

At the right of the main entrance, the *Encyclopaedia Britannica* sponsored the Ready Reference Center. This model reference facility was staffed by professional reference librarians and supplied with some 730 selected reference books by several domestic publishers. The books were selected by a committee of librarians working with the Reference Services Division of ALA. Professional librarians and assistants provided the Fair-goer with an example of the best "quick" reference service. The teak shelves and reference desk were provided by NorsCo of Los Angeles, and the Xerox Corporation provided a 914 Copier.

Beyond the reference center, an adult non-fiction browsing collection of books was provided for the Fair visitors, sponsored by the "Great Books of the Western World" of the *Encyclopaedia Britannica*. Approximately 800 selected books were provided by publishers. Book jackets were supplied by Demco Library Supplies. Comfortable lounge furniture was provided by Herman Miller, Inc. In an especially attractive teak display case, a facsimile copy of the Gutenberg Bible was shown, loaned by Bowdoin College.

The special needs of students at the secondary level were the concern of the Learning Resources Center which occupied one-half of the second circular display area. Sponsored by the U.S. Office of Education through a contract with the University of Washington, the display included a model "quest" space for individual study. Equipment such as closed-circuit television, telephone, auto-tutor, and dual-channel tape desk were shown as special supplements to the normal study materials used by individual high school students. Nearby, additional equipment such as a Memo-tutor, microfilm reader-printer, phonograph, radio, Speed Reader, Flash-X, electronic panels, microcard readers, and microfilm reader were displayed. All of this equipment, it was suggested, might be made available in a regional resource center within a school

system. Students would be able to use this special equipment as needed to supplement normal book and library resources presently available to them. The exhibit conceptualized the increasing emphasis on individual responsibility for learning and the vast resources that will be available to the student from the center in his school building, or at the district level, as well as from other sources in his city, state, nation, or countries elsewhere in the world. Specific subjects for displays were language arts, science, social studies, and fine arts. Extensive reference materials were available to visitors on sources of existing materials and equipment and their uses.

Duplicate equipment, arranged on teak shelving supplied by NorsCo, permitted the general public to manipulate the various items shown in the display. A professional librarian was available to explain the "quest space" and regional-resource center concepts and to answer questions relating to the use of this kind of equipment. A souvenir microcard containing the LIBRARY-21 story and 48 pages of the official guidebook of the Seattle World's Fair was provided by the Microcard Corp. of West Salem, Wisconsin. Over 135,000 cards were distributed to exhibit visitors. Electronic Teaching Laboratories, of Washington, D.C., served as coordinators of the theme and equipment displays; and a wide variety of companies in the newer educational-media field assisted in the organization of the Learning Resources Center.

The central portion of the second circular display area was occupied by a circular theatre, 32 feet in diameter, sponsored by the Xerox Corporation. The theatre involved a specially designed multiple-projector technique to display an eight-minute film entitled "LIBRARY-21," produced by Visualscope, Inc., of New York. During the Fair, 239,000 persons viewed the film which presented the historical growth of graphic communication, outlined the complexities of the present situation, and suggested the contributions of xerography to the solution of the problem.

In the remaining portion of the second circular display area, the Radio Corporation of America sponsored a display suggesting a world-wide communication network utilizing satellites for the transmission of documents and information from one part of the world to another. It portrayed the

potentiality for using documents which are stored in regional centers but which can become immediately accessible to scholars in remote locations by the use of equipment similar to television.

Nearby, the National Cash Register Company demonstrated its recently developed technique called "Photochromic Microimages," by which printed material can be stored on film plates in linear reduction of 200:1. This novel technique reduces printed matter to microscopic size and, at the same time, makes it easy to duplicate and distribute. The process of reducing documents 200 times and more means that a 400-page book can be diminished to the size of a postage stamp, but selected images can be magnified for reading or duplication.

Below the main exhibit level, the ALA provided a room called the "Children's World." A committee of the Children's Services Division carefully selected a collection of foreign and domestic children's books. The books were provided by many publishers and covered by Bro-Dart Plasti-Kleer jackets, and displayed on NorsCo teak shelving. Appropriate tables and chairs by Herman-Miller, Inc., gave visiting children and adults an opportunity to comfortably inspect and read the books. In a small theatre which seated 20 children on stools professional librarians told stories, showed special children's movies, or used film-strips. The movies were supplied by Encyclopaedia Britannica Films and the National Film Board of Canada. The Film strips were from Weston Woods, Inc.

From the earliest planning stages of LIBRARY-21, the ALA Advisory Committee believed that the exhibit could be interpreted to the public only through the use of professional librarians. This was especially important in such areas as the Ready Reference Center, the Learning Resources Center and the Children's World where the promotion of library use and the interpretation of future developments could be handled best by persons with professional library backgrounds.

The exhibit's professional staff of librarians assisted the public in understanding the implications of the library's use of the new media. The purpose of this interaction between the public and the librarian was threefold: (1) to provide librarians with an educational experience in a machine-library environment; (2) to explore professional reaction

to the introduction of such entirely new concepts; and (3) to evolve valid criteria for the development of advanced library-education curricula. Librarians were selected from 15 states, and one each from Mexico (an American citizen), Germany (U.S. Air Force personnel) and Canada (a Canadian citizen). With one exception, they all had received degrees from accredited library schools.

The ALA delegated the responsibilities for staffing and for conducting the program of education to the School of Librarianship of the University of Washington. This was made possible by a grant from the Office of Education of the Department of Health, Education, and Welfare under Title VII of the National Defense Education Act.

The training of the staff was undertaken by Dr. Robert M. Hayes of Los Angeles, who was attached to the School of Librarianship of the University of Washington. The first five groups of li-

brarians were trained on the campus of the University of Washington; the sixth and last group was trained on the Fair grounds. One purpose of the training program was to expose professional librarians to the comprehensive history and present state of the computer art, with some exploration of its potential for library operations. All concerned though that this was an important goal to achieve; as a result of it these staff members would return to their communities with an awareness of present technology and some willingness to explore its possible uses in their own libraries. A second purpose, less important from the long-range point of view, was to train the staff for their duties at the exhibit. Most of the staff benefited greatly from the training course, became realists about automation and mechanization in libraries, and developed great enthusiasm for promoting such devices in their own libraries and elsewhere.

ASSUMPTIONS ABOUT LIBRARY AUTOMATION

Early Technology

Librarians have long been interested in technology. If one scans the pages of professional library journals published at the turn of the century, he encounters references to the usefulness and value of labor-saving devices in libraries. At that time, librarians coined the phrase "mechanical aids" to describe the gadgets that were first designed to improve selected processes of book handling.

We regard early activity in "library technology" as the beginning of the current trend toward automation in the field of information processing. At first, this activity was focused almost exclusively on improving methods for the technical processing of a book as a unit. Today, however, we are interested in extending automation into other areas of library activity—reference service, circulation, cataloging, interlibrary communication, etc.

Modern Planning

The planners of modern libraries consider and adopt many recent technological advances in order to make the physical environment of libraries more pleasant and more functional. They have made remarkable progress in developing functional lighting, controlled acoustics, imaginative color schemes,

structural design, air conditioning, humidity and dust control, and comfortable furnishings. The application of operations research techniques also ensures the integration of optimum conditions for work-flow into library architectural design and construction.

Teaching machines and language laboratories are characteristic of the newer media which are fast becoming part of the library scene. Many librarians also are anticipating extended use of audio-visual material and equipment.

With the advent of data-processing equipment, librarians are speculating that machines eventually may perform information operations which closely resemble those now being performed by humans. Computers are used extensively in government and industry for process control, business-data-processing, and scientific computation; therefore, their eventual application in the areas of information retrieval and mechanical translation seems more than sheer speculation. Investigators and researchers have already demonstrated through mathematical modeling that the powerful capabilities of a computer can be directed to ingeniously perform some information tasks. Accordingly, members of a variety of disciplines are conducting fundamental research to improve existing methods of organiz-

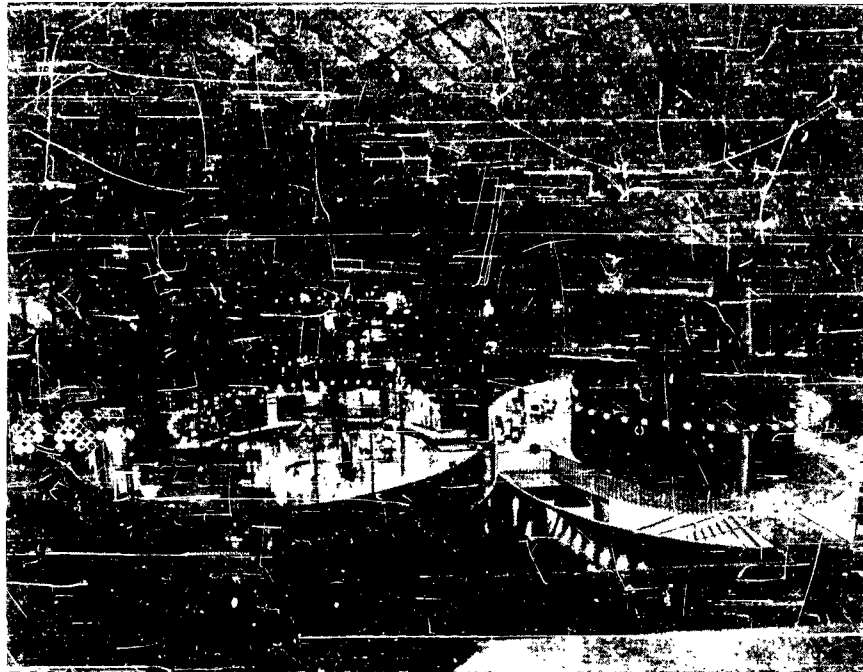


FIGURE 1 Photo by Morley
View of entire LIBRARY-21 Exhibit. Main entrance at the left of photo.

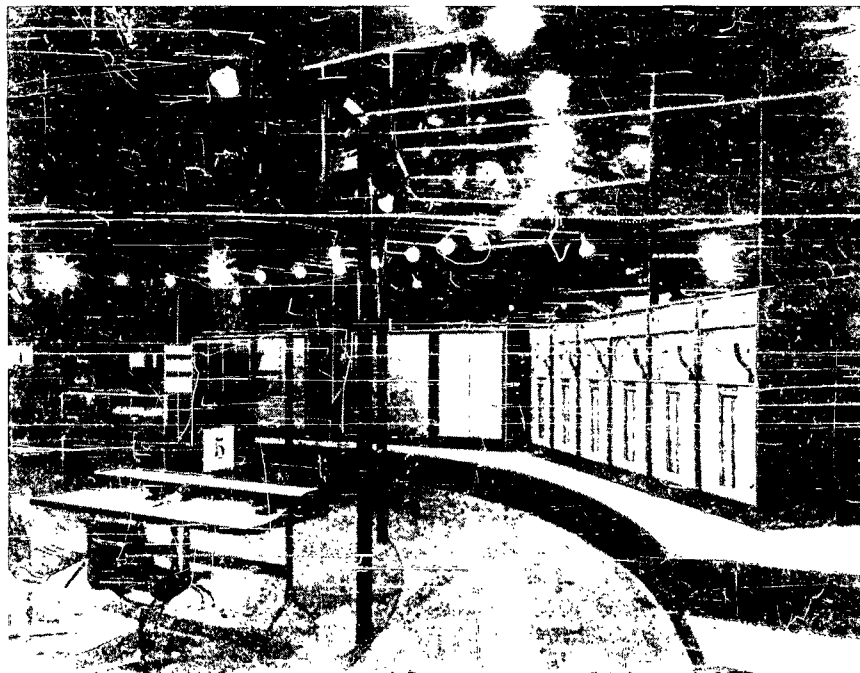


FIGURE 2
First circle exhibit area showing
Sperry Rand Univac Solid State 90 Computer.

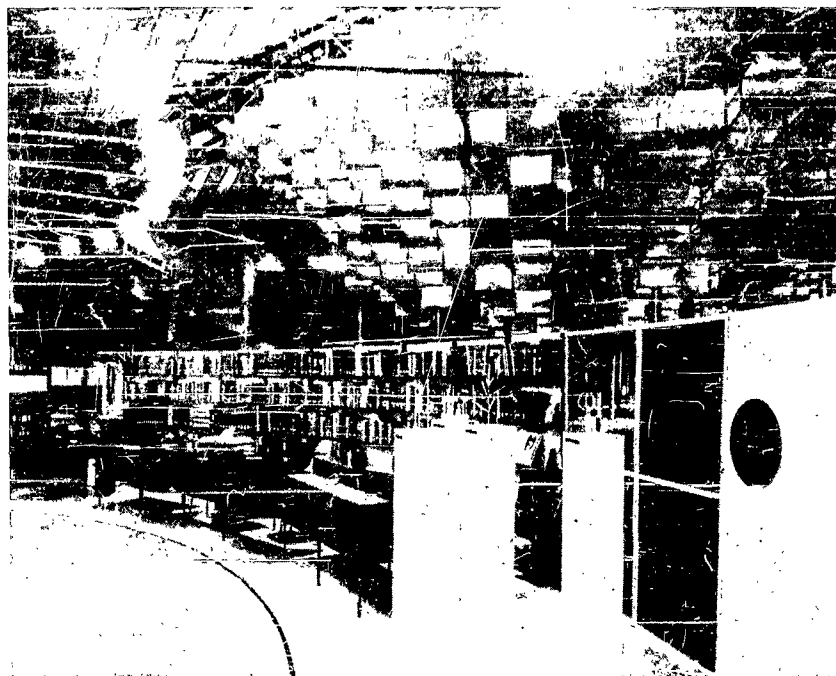


FIGURE 3

Photo by Morley

Ready Reference Center, sponsored by Encyclopaedia Britannica.

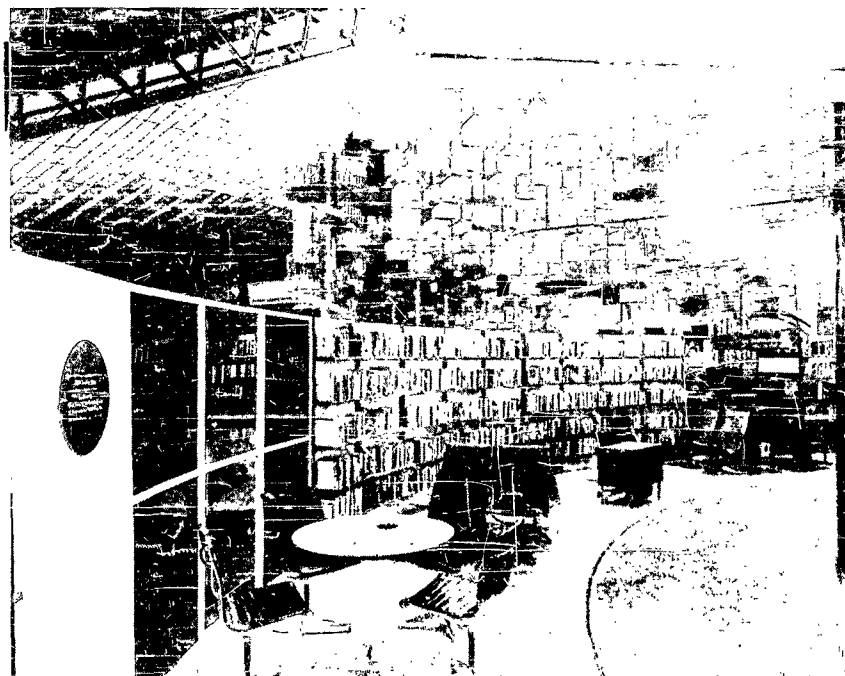


FIGURE 4

Photo by Morley

Adult Reading Area, sponsored by Great Books of the Western World,
a division of Encyclopaedia Britannica.

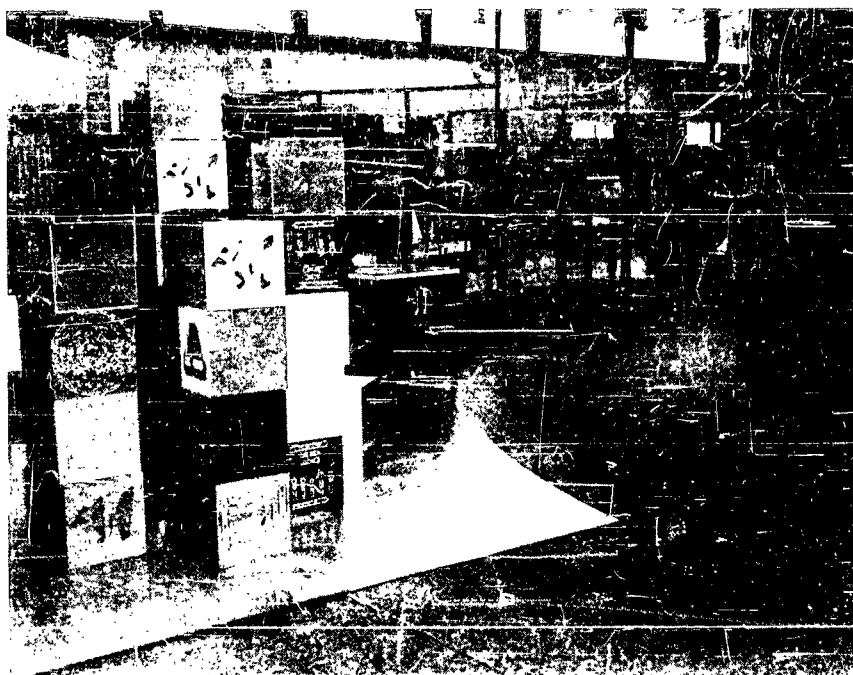


FIGURE 5

Photo by Martin

Learning Resources Center, sponsored by U.S. Office of Education.

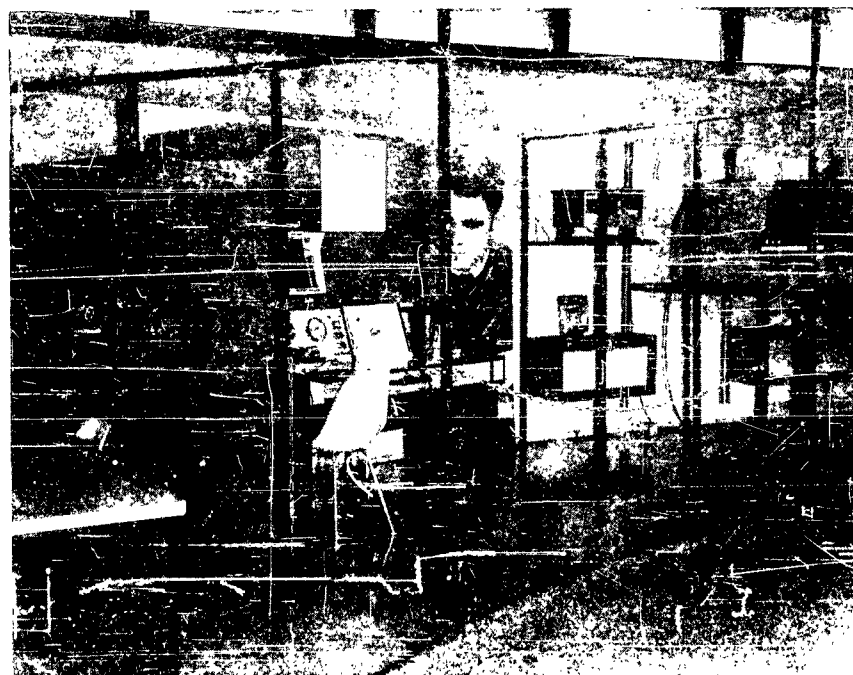


FIGURE 6

Photo by Martin

Learning Resources Center, showing model individual study space,
or "quest" space.

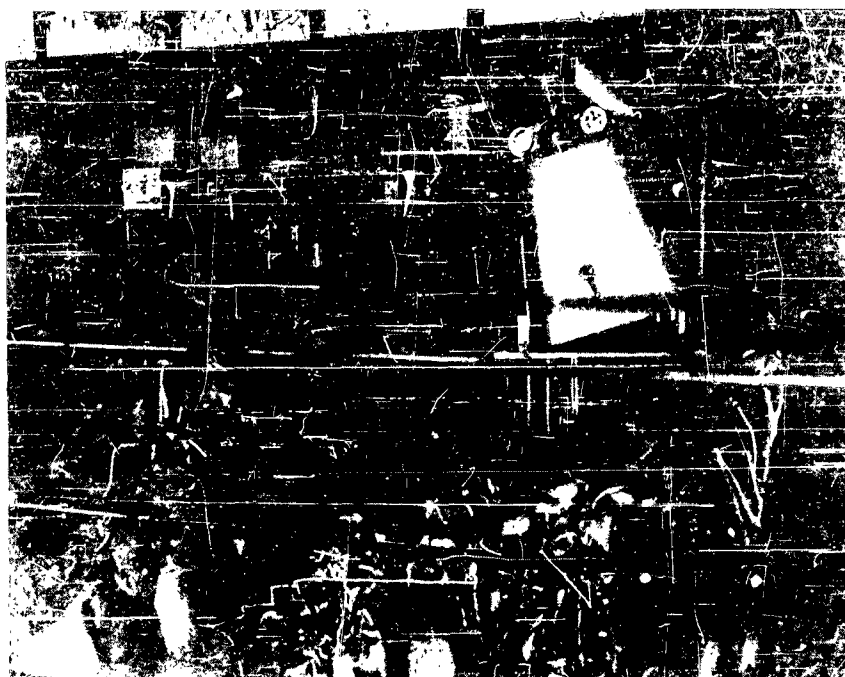


FIGURE 7

Photo by Martin

Learning Resources Center, showing equipment available to public.

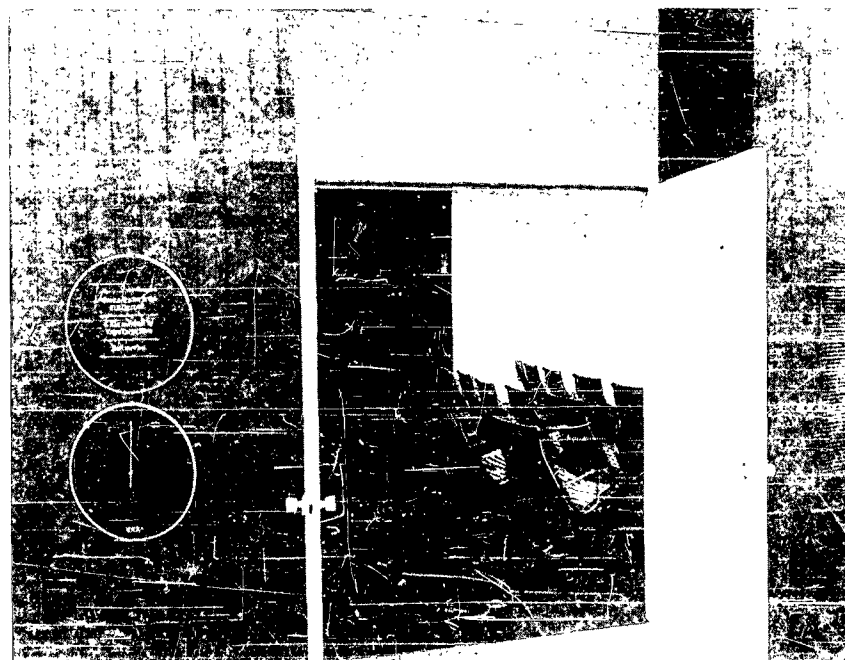


FIGURE 8

Photo by Martin

Xerox Theatre. Film entitled "LIBRARY-21," shown by a six-projector technique, was exhibited every 15 minutes during the day. Theatre sponsored by the Xerox Corporation.



FIGURE 9

Photo by Morley

**Global Library System display sponsored by Radio Corporation of America,
and the Photochromic Micro-images display sponsored by
National Cash Register Company.**



FIGURE 10

Photo by Morley

**The Children's World, sponsored by the Children's Services Division, ALA.
The foreground shows the reading area, in the distance the small theatre,
and at the left the exit from the maze.**

ing and communicating information. This research includes studies in mathematical linguistics, mechanical translation, pattern recognition, artificial intelligence, the theory of information storage and retrieval, classification theory, etc.

This widespread interest in research shown by many professions, including the library profession, is indicative of the importance and pressing nature of the information problem. Government and industrial research groups are faced with a critical situation because the rate at which information is being published is climbing exponentially. As the world grows smaller and the requirement to communicate grows more complex, this situation is intensified. If information is an important national resource, then the rate of our national growth is keyed to our ability to make optimum use of this resource. Hence, library planners are attempting to keep abreast of scientific techniques and machine automation, continually evaluating them for possible application to the information systems of the future.

Within the past year, large government information repositories like the Library of Congress, the National Library of Medicine, the National Aeronautics and Space Administration (NASA), and the Armed Services Technical Information Agency (ASTIA) have each taken additional steps toward finding automated solutions to the problems of bibliographical control of information and printed materials.

Future Assumptions

Any attempt to plan for the future inevitably requires the forecaster to adopt one of two approaches. Either he must consider future developments as extensions of current ones—within the context of what he knows and understands—or he must deliberately overstep the bounds of the real world and try to define a new image. Jules Verne successfully did the latter. His predictions came true, and, with hindsight, we now credit him with a good imagination. Some of his contemporaries, however, were inclined to view his prognostications with disbelief and alarm. Although the principle of electricity, for example, was known before 1862, very few men had conceived and verbalized with any degree of certainty those applications of the principle that exist in 1963.

In this report, the ALA has taken the steadiest course possible by making certain basic assumptions which can be used as a framework for discussion and comment, noting the changes and effects wrought by technology in present library operations, and projecting ideas far into the future. The assumptions listed below set the background for the report:

1. The Man of the Future

The patron, the man of the future, will have greater opportunities to be aware of his culture. Men of all nations will be more literate and will thirst for a communication of ideas. In 50 years the now unrecognized culture of today's backward nations will be a commonplace topic.

2. The Society of the Future

Continued improvements in transportation and communication will disperse the urban man and, along with him, the interests that he developed in a "cosmopolitan" society. The gradual mixing of societies, nationalities, and pursuits will eventually lead to an amalgamation of interests. The interests of rural men of the future will be as broad and varied as they are in any densely populated urban area of today. A rural town in Wisconsin and a suburb of Los Angeles will require the same kind of information resources. The need for medical or legal information resources will be universal.

3. The Library of the Future

The library of the future will encompass every form of man's knowledge. It will be a continually expanding warehouse of both historical and current information.

The library of the future will be constructed on present-day foundations and will probably evolve as a combined form of the conventional and special library as we know them today. It will reflect forthcoming sociological and technological changes. For the most part, the sociological aspects are predictable. These will be man's increased appetite for knowledge and how he will relate himself to the culture that will be available. Advances in technology will permit easy and inexpensive communication with other information facilities.

Printed materials will remain basic to all educational and civilized thought, but new media such as film, television, audio devices, and data-processing and information-retrieval machines, as well as

advances in communications, will increasingly serve as complementary information resources.

4. *Research Needs of the Future*

Science and technology within U.S. industry and throughout the Government will continue to expand at geometric rates. Electronics, space tech-

nology, and bionics are but a few of the areas most likely to advance and expand with our national growth. Through vast economic and medical research programs, great emphasis will be placed on improving services to man and on eliminating hunger, want, and pain. Optimum use of research resources will become a primary national goal.

LIBRARY-21 PLANNING CONSIDERATIONS

It was not possible to incorporate into the final exhibit all of the ideas originally conceived by the LIBRARY-21 staff and the Advisory Committee. However, it may be useful to describe briefly the suppositions and assumptions about an electronic information center which were originally introduced and which served as guidelines in the evolution of the final form.

Three areas of conventional library service were singled out as those most likely to be affected sufficiently by change to make them candidates for treatment in LIBRARY-21: Special Services, Information Services, and Technical Services. Special Services included the variety of new techniques which will be introduced to satisfy the particular needs of special interest groups; Information Services included the diverse methods and techniques of storage and retrieval available for general-reference use; and Technical Services embraced the application of equipment to behind-the-scenes library-processing operations. Limited examples are given below for purposes of illustration:

1. *Special Services*

a. **THE HANDICAPPED**—In the future, blind persons will have more versatile access to recorded knowledge. One of the principal media to be improved upon is audio recording. The blind are now able to "read" books by borrowing long-playing records from local libraries or buying specially designed record players for use at home! In the future, they will have "dial-a-book" available to them in an electronic information center. Just as we get the local weather forecast by dialing a prescribed number on our home telephone, so it will be possible for a blind person to phone his local electronic information center and, with the appropriate machine code, to dial and tune in

directly to the contents of a book of his choice. The book might be stored as signals on a magnetic tape in cartridge form. A switching system might allow the user automatically to locate the desired cartridge through tactile means and then play it back over the telephone circuit; further controls would be regulated from the user's home. This special service would be available not only to the blind, but also to any individual who desired information from the center, provided, of course, that it was stored in audio-recorded form.

For the deaf, the center will make available "video cassettes," which are specially designed educational films recorded on video tape, some containing verbal information particularly suited for visual comprehension by the deaf. Video cassettes could be borrowed for use at home by plugging them into a television set, or they could be communicated by electrical means from the library to the home on a request basis. They, too, could be used by any other library patron in search of information.

b. **ART AND MUSIC**—The techniques described above certainly indicate the possibility that art and music could become more widely available to the public through improved communications between the home and the library. Through the telephone and the television receiver, it will be possible to provide any of the library's treasures for enjoyment at home. The very fact that audio and video materials lend themselves so readily to the common communication media enhances the notion that materials in distant libraries could be obtained by libraries and switched into the home of the requester.

c. **SELF-EDUCATION**—In tomorrow's information complex, opportunities will exist for self-

learning and individual instruction. Libraries today provide patrons with access to books, records, and films; tomorrow's information center will also contain individual "quest" booths equipped with teaching machines, tape recorders, and micro-projectors. It should be possible for an individual to study his chosen subject with freedom to select not only book material, but also self-instructional material. Library stacks undoubtedly will contain forms of information other than the printed form, such as magnetic tapes, film, audio tapes, video tapes, etc.

The electronic information center will reflect increasing emphasis on individual responsibility for learning and will probably be tied into the school system through a communication network. The body of knowledge in the center will serve as an integral part of a pupil's school curriculum and be a source for his self-education as well. A learning resources area within the center will facilitate this kind of library-school relationship.

Physically, the learning resources area will contain individual study rooms, or "Q-spaces," containing books and the newer educational booth. Here a student would be able to dial the learning-resources area for his combination film and master tape lesson. A closed-circuit television channel would present the visual material to him, and his audio-receiver would be activated to begin his practice of pronunciation. He might very well have a telephone pal instead of a pen pal in France, and, working from the booth, could exchange conversations in French and English with his foreign friend.

Another example of the use of an individual study space might be in the preparation of a social studies assignment, let us say on a topic like the Civil War. A student could request from the information-retrieval facility a bibliography that would be tailored to his individual needs and capabilities. At his television screen, he could browse through microfilm reproductions of various Northern and Southern newspapers, and make instantaneous reproductions of the passages most pertinent to his project outline. Background film,

historical pictures, and even music of the period might be used to help him get the feeling of the time and setting of the events.

The whole purpose of the individual study area will be to open up the vast resources of knowledge available in and through the electronic information center for direct use by the student on an individual basis.

2. Information Services Area

This area will be the heart of the advanced techniques which will be available in the electronic information center. Through machine information storage and retrieval, it will supplement and strengthen what we now recognize as conventional library-reference activities. The major function of this area will be to provide access to information stored in digital form and available in the same form for communication to and from remote points.

Four possible functions of this area are: remote inquiry and automatic catalog search, personalized bibliographies, display of facts and statistics, and machine translation.

Remote inquiry and automatic catalog search will make it possible to answer questions from remote stations—homes, offices, schools, or regional information centers. The objectives will be to permit an individual to obtain detailed information about a topic of interest. A pre-punched card will serve to identify the requester, and his request could be made either in written or oral form. The printed or video response will contain the correct answer and supply the bibliographic citation. By providing a language key in the remote input device, the response could be printed in any language. The main data-processing complex will be centrally located in the information center and will be the main source of information for the remote stations. The facility will contain large-scale digital computers with very large random-access memories. The remote stations will communicate with the computers by microwave or laser beams.

Remote stations will be operable by anyone, and, consequently, the devices themselves will be designed to be as foolproof as the telephone. The computers will respond

simultaneously to any number of inquiries. Video techniques will be used for catalog research. Via closed-circuit, ultra-frequency television, it will be possible to browse through either card or magnetic-tape catalogs and be unrestricted by their physical location or size. This facet of the center's operations will lean most heavily on communication links.

Personalized bibliographies will supplement normal bibliographic information recorded for reader use; the information center will record "suitability" information in connection with each item stored. Requests then can be made to the center's information store, and, based on the criteria of age, educational background, and language, the computer will respond with a bibliography tailored to an individual's particular combination of criteria. The computer's program will compute the requester's suitability score, examine the request for limitations, and print out copies of pertinent materials.

Through display of facts and statistics the center will emphasize information of popular interest. It is quite likely that the center will also serve as the community's news center. Accordingly, it will play a more active role in openly featuring information about current events.

Dynamic visual displays will be an integral part of the center. And, based on their own statistical extrapolations or on receipt of more current data, computer programs will periodically revise the display information. Various reporting media will input news information as it happens, together with suitable background in graphic and written form.

The prospect of machine translation offers considerable promise for breaking down language barriers to human communication. The center will probably retain information in the language in which it was prepared, but will automatically translate it into any language understood by the requester.

3. Technical Services

a. **MICRO-STORAGE** — Microphotography, kalvar tape, and other forms of file condensation make possible the reduction of secondary files and archives to minimal size, thus allow-

ing libraries to carry larger research resources. Besides serving the purpose of compactness, these recording media may be used to store materials of a current or temporary nature. A microform record would make it unnecessary for local libraries to store a five-year accumulation of ten different newspapers.

With the appearance of more efficient office reproduction equipment, libraries in the future may be able to duplicate their records for their clients instead of circulating unique copies for them. The material would be provided in the form of film, tape, or an enlarged facsimile image.

b. **DOCUMENT REPRODUCTION** — For those publications not falling within the jurisdiction of copyright regulations, the technical services area will provide take-home duplication service. The original information will either be carried on bound form on reference shelves, in reduced form on film or tape, or in digital form in the central computer. Original volumes may be facsimile copies or character scanned and printed by high-speed printing techniques. Filmed data may be recreated back into paper from its microfilm or read on a film viewer—with only desired pages reproduced from the viewing screen. Computer-stored information may be read by printer or by a volatile display and reproduced as required.

All forms of reproduction will be used by regional information centers. Statisticians and operations researchers will assist the technical services personnel in determining what forms of storage and reproduction are most appropriate for certain documents. Reproduction techniques will facilitate the preservation of valuable original documents and will allow libraries to temporarily store information of current value and carry rarely circulated but valuable resource materials.

c. **DISPLAYS**—Volatile displays will be the principal form of communication between a local electronic information center and its regional affiliates. These units will be small devices installed in information centers, in research libraries, in medical offices, in government establishments, and possibly in certain

homes. It will be the ticker tape of the future with an infinitely vast information resource.

The television raster-scan techniques of today will be replaced by internal character-generating mechanisms to eliminate the residual glow of the phosphor on TV-type tubes. Contrast will be sharper, and the images more readable. A library patron will scan the file containing these displays and, whenever he desires, copy the image for his own permanent use. Cathode ray tube displays will be supplemented with film projections, electroluminescent panels, and ultrasonic cavitation displays as required by the situation.

d. AUTOMATIC HANDLING — The automatic conveyors handling materials at the book check-in desk at the library's main entrance are but one part of a vast material-handling network. From the time a book or a document is received, the entire handling sequence will be controlled but not handled by library personnel.

New library materials will be checked automatically against shipping invoices by magnetic tape readers, magnetic film readers, mark sensors, character readers, or numeral readers. The title, author, publisher, and table of contents will be scanned and indexed by central reference or by pre-prepared indexing plans.

Browsing materials will be placed on shelves in topical sequence. Reference and research materials will be placed in the library in random order. For the latter, patrons will rely entirely on automatic card catalogs or computer look-up files.

e. INTELLICTRONICS — The computer of the library system, which will be organized and maintained by the technical services personnel, will operate in four modes. The first of these will be literally a computing machine for those with research problems in information theory and the like; the second will be a look-up file for patrons with a specific topical interest who may want a bibliography of current books to read; the third will be a literature-searching machine for those who must scan the content of all materials for pertinent information; and the fourth will be an analytic device which will allow an advanced patron to converse with the computer on complex problems, gradually approaching a solution through a series of iterative answers.

The computer will be the mass-information-storage mechanism of the library for research materials. It will be the switching center for interlibrary communications. It will organize and control requests coming into the library from remote regional centers, maintain the business records of the library and a current inventory of all materials, and will contain the organization of languages for translations. It will store the learning resources of the teaching machines and be the electronic nerve of the regional system.

Practical limitations of time and money prevented ALA from demonstrating all of the ideas expressed above. However, LIBRARY-21 did incorporate as many as could reasonably be accommodated. None of the described devices or techniques is technically infeasible—all would have been included if the resources had been available.

II. CONCEPT OF A NATIONAL INFORMATION NETWORK

PRESENT LIBRARY NETWORKS

The futuristic regional information relationships, facilities, and services considered for LIBRARY-21 and described in Section I are firmly based upon years of manual-operating experience in libraries. Cooperation among libraries, to assure the best use of existing facilities and resources, is historical and has led to services and network arrangements of fundamental importance to the library of tomorrow. To the extent that "the past is prologue," we believe it will be helpful to review briefly some of these cooperative services and prevailing network schemes.

Examples at the highest level are found in the three great national libraries of the United States—the Library of Congress, the National Library of Medicine and the National Agricultural Library. Relationships between these three, although not as closely defined as would be ideally desired, actually provide the major elements of a national library system. An extreme oversimplification of their acquisition policies and canons of selection is to say that the National Agricultural Library collects everything in the field of technical agriculture, the National Library of Medicine in the field of clinical medicine, and the Library of Congress—'everything else'.

The attempts of this national library system to make these resources available through specialized services and organizational patterns are reflected in much of tomorrow's planning.

The Library of Congress, as the one institution in the American library world most closely approximating a national library in the true sense, embodies many services and facilities of a "network" nature. Its card-distribution service represents a substantial contribution toward relieving many American libraries of the burden of cataloging individual books. Sets of cards provided by the Library of Congress are used in many cases for both descriptive cataloging—author, title, and imprint—and for subject cataloging and classification by those libraries employing the Library of Congress subject-heading and classification schedules.

As a by-product of this service, the Library of

Congress will also provide proof-sheets of forthcoming cards. Appearing well in advance of actual printed cards, these sheets enable many libraries to select books for acquisition which have been added to the Library of Congress but may have escaped notice through normal bibliographic channels.

Cards for many volumes not actually owned by the Library of Congress are included in its card service. These represent a cooperative cataloging service in which participating institutions provide cataloging copy. The advantage of this system is similar to that outlined above—elimination of unnecessary duplication of effort. Many of the cards printed by the Library of Congress for books in other libraries have been acquired through the Farmington Plan, an ambitious undertaking of a large group of research libraries in this country. The purpose of the Plan is to insure adequate coverage for all the important bibliographic and geographic areas of the world. Individual libraries are assigned geographic areas (specific countries such as Angola, Liberia, or Togo) as well as particular subject areas (mathematics, history of science, theatre). Book dealers are designated in each country covered by the Farmington Plan—actually most of the non-Communist world—and it is their responsibility to send books to designated libraries on the basis of assigned areas of responsibility. While complete coverage is still to be achieved, steps have been taken toward the goal of having one copy of every important book published anywhere in the world in some American library.

The National Union Catalog (NUC) maintained at the Library of Congress is another example of a network in action. While the success of the system relies heavily on the cooperation of the participants, the amount of work incumbent on individual institutions is minimal in that it is built in with the actual processing of books by libraries. Libraries send cards for books they have added to their own collections to the National Union Catalog, and this information is posted in a master file. The Catalog itself is published periodically in book form and enables libraries to

identify locations for wanted materials not in their own collections. Between publishing of the printed lists, libraries may request locations of wanted books directly from the NUC. A weekly listing of previously unlocated items is circulated to cooperating libraries.

The concept of a central file of holdings of various institutions, as described above, has been functioning for a long time in the area of periodicals and serials. The *Union List of Serials* and its successor, *New Serial Titles*, are composite lists of holdings of a vast network of university, college, public, and research libraries. No library can possibly subscribe to or maintain files of all the periodicals it will ever need. A union list enables libraries to identify quickly the location of a particular volume of a particular title and to get either the original or a copy in a reasonably short period of time. The efficiency and relatively low cost of modern copying methods have greatly reduced the borrowing of periodicals in recent years, but the need to know the locations of serial titles will undoubtedly insure the continuance of union list publications.

Both the union catalog and the union list type of operation have been functioning successfully on a regional or subject level. The Philadelphia Bibliographic Center contains a union catalog of holdings of libraries in that general area. There is a *Union List of Serials in New Jersey*, as well as in other states, which include the holdings, of many industrial and special libraries.

The most notable—not normally included in the national lists—is that provided by *Chemical Abstracts*. The list includes periodicals and the subjects discussed in them and the names of libraries holding individual titles, with an indication of whether the library will lend, photocopy, or microfilm.

Before proceeding to the many important and varied governmental library-network operations, mention should be made of one of the most elemental yet essential type of networks. It is the one provided by library-accession lists. While often taken for granted by those most directly involved, accession lists, or lists of acquisitions of libraries of various types, are highly useful. When a large university library which collects specialized materials uses normal bibliographic means, it will find

that important data have been overlooked in the acquisitions lists of such organizations as the Naval Civil Engineering Laboratory, the David Taylor Model Basin, the Army Corps of Engineers, the many special libraries maintained by the Air Force, and the myriad special industrial and research libraries. Until we achieve more sophisticated information networks, this rudimentary yet highly valuable network will probably continue to operate at various levels in the library economy.

One of the most successful government-sponsored networks is that of the Armed Services Technical Information Agency (ASTIA). As an arm of the Department of Defense, ASTIA is responsible for collecting and maintaining files of reports of all groups doing research under contract to the Department. Copies of reports generated under government contract are forwarded regularly to ASTIA, which is responsible for filing and making them available to all other groups doing similar government-sponsored research. Periodic listings of available reports appear in the *Technical Abstract Bulletin*, and individual reports are supplied on request.

The Office of Technical Services (OTS) of the Department of Commerce is, in essence, a "civilian" counterpart to ASTIA. Utilizing some of the bibliographic information provided by ASTIA, OTS is responsible for the announcement and dissemination of research-and-development literature sponsored both directly and indirectly by the Government. Through the medium of *U.S. Government Research Reports*, frequent announcement of available publications is made, and OTS also is responsible for the distribution of materials. In cooperation with the Special Libraries Association, OTS is actively engaged in a translation-bibliographic effort by which most of the literature currently being translated in this country is made generally available. For several years, OTS has operated a system of regional depository libraries. Twelve centers have been set up which receive files of reports and maintain them for a specific geographic area. The Massachusetts Institute of Technology library serves Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. The Linda Hall Library in Kansas City similarly serves Arkansas, Iowa, Kansas, Missouri, and Nebraska. Library centers have been set up for certain types of OTS reports and for files of translations.

The Atomic Energy Commission (AEC) is another agency of the Federal Government which has a vast network of depository libraries engaged in the collection and dissemination of technical information. Almost 90 depository libraries in the United States and its possessions and nearly 100 such locations abroad contain collections of AEC reports for reference by the general public. The Commission makes available to these libraries reports produced both within this country and within other countries cooperating in this project.

Another project in library cooperation is commonly referred to as P.L. (Public Law) 480.² Through the purchase of foreign currencies in the United Arab Republic, India, and Pakistan, ten sets of complete current publications are to be secured and sent to selected libraries which already have substantial holdings in these countries. The Library of Congress has undertaken to catalog the Indian and Pakistani material for all the cooperating libraries; Princeton University is cataloging the Arabic material. Cards are being printed by the Library of Congress and are being distributed to the various cooperating institutions.

The above list of cooperative bibliographic operations is impressive but by no means complete. There are, for example, such operations as the Midwest Interlibrary Center which stores little-used material of a large group of university libraries. The sharing of resources and the elimination of duplicate files of lesser-used materials provides a substantial saving in both space and money. The goal of the newspaper microfilming project of the Association of Research Libraries is to guarantee a usable central file of every important foreign newspaper now stored on film somewhere in the United States.

The history of libraries in the United States and abroad is the history of cooperation and improvisation in acquiring and disseminating information through local, regional, national, and international undertakings. The efforts and experiences mentioned here are only a few of the vital elements which library service of yesterday and today are contributing to the network services of tomorrow.

² U.S. Laws Statutes, etc. Agricultural Development Assistance Act of 1954. (Public Law 480, 83rd Cong., 68 Stat. 454.)

AUTOMATED REGIONAL INFORMATION CENTER

The impressive review of technology, which follows in Section III, and the variety of demonstrable equipment and techniques at LIBRARY-21 are evidence of the increasing interest in automation that today characterizes the field of the information sciences. While it is generally recognized that the cost of converting our existing manual information networks is prohibitively expensive, there is no letup in the trend toward further experimentation. Automation in the information area seems inevitable in the future, and there is good reason to believe that the electronic information center will become a reality long before the Twenty-first Century.

Present systems of information storage and retrieval satisfy in large measure our individual desires for education and recreation. The pleasure of holding and reading a book, for example, is an experience which few have even the remotest interest in replacing at this point in time.

One thing seems clear: automation is not apt to serve as a substitute for all of the conventional manual information systems which usefully exist today. The printed index, the book catalog, and other reference tools are expected to continue to flourish in those areas of work where their efficiency and economy are recognized. The addition of mechanized or electronic information tools will serve as extensions of present capabilities by providing a complementary method for storing and retrieving data.

Therefore, if automation does arrive on the library scene, it will probably not appear first in our public or school libraries. It is more apt to occur in special and research libraries where—particularly in the fields of science and technology—literature and new information is overwhelming the researcher.

Currently, the demands of our national scientific and technical programs are so intense that billions of dollars are spent by the Government and

industry each year in support of research and development. These efforts eventually result in printed items which have meaning and impact on opposite points of the total scientific community. On an item-for-item basis, it appears that the volume of scientific and technical reports is greater today than the amount of books and periodicals that roll off our commercial printing presses and are customarily cataloged in libraries. Not only is the quantity of these reports staggering, but also there is no equivalent library-type mechanism, in or out of government, for recording and controlling access to the information they contain.

ASTIA and OTS, described earlier, do attempt to organize segments of the total input. Nonetheless, there is a vast quantity of research and development information which does not find its way into the dissemination stream. This is not a temporary problem because we expect more, rather than less, printed scientific and technical literature in the future. In order to keep our national research programs vigorous and to make certain that our scientific researchers are well informed, we need somehow to find new methods and techniques for disseminating, indexing, and storing the facts, figures, and conclusions which derive from our multi billion dollar research programs. *Unless we inject some effective anti-coagulants into our information-processing system, we can look forward to gradual hardening of the research arteries.*

DESCRIPTION OF A TYPICAL CENTER

Let us say that this center would concentrate solely on the report literature generated under contract by those performing scientific and engineering research and development work for the Government. It is realistic to select this field because it is one inadequately covered by manual or semi-mechanized controls, and it is one in which there is a pressing, critical need for current awareness and retrospective research. According to U.S. Senate reports, the defense establishment would benefit greatly by coordinating efforts in this field.⁴

A recent Department of Defense (DOD) directive calls for "vigorous, well-organized, thoroughly coordinated, comprehensive technical programs" providing for "the interchange of technical information within DOD, between DOD and its con-

Conventional library methods for book and periodical processing occur *after* information appears in print. Also, libraries accept and tolerate a multiplicity of *different* information formats at the source of publication. Finally, they arrange things so that all items come to one place for central processing. These methods are recognized as being satisfactory and worthwhile when the volume of work remains small—but when the volume increases geometrically, as is the case in scientific and technical report literature, then it would seem that we need a basic change in system philosophy.

Given the high stakes involved in building information automation as a national resource, it is reasonable to assume that the U.S. Government is apt to take the lead. The pressing needs of our national research and development programs in the aerospace sciences or in electronics would easily justify the establishment of a centralized information processing facility that would serve regional centers throughout the country via communication links.

For purposes of illustration, the next portion of this section postulates the creation of such a government-operated electronic information center connected to and serving the major private and governmental information establishments in the country. It is advanced here to inject some realism into the discussion and to introduce the description of the proposed network of information centers that appears later.

tractors, between DOD and other Federal agencies and their contractors, and between DOD and the scientific and technical community to the maximum extent permitted by security."

The DOD scientific and technical information program provides "for the handling and dissemination of technical data and documents or their abstracts, the publishing of technical journals, the preparation and conduct of technical meetings and symposia, and the dissemination of information acquired by all other means, that are products of or are in direct support of DOD research, development, test and evaluation processes, the manage-

⁴ Department of Defense Appropriation Bill, 1963. (Report No. 1578) Senate, 87th Congress, 2nd Session, 1962, p. 10.

ment thereof, through the phase of design release to production."

Modern techniques, including the use of computer-type equipment where effective and efficient, will be used in the information programs. And the greatest possible participation in, and compatibility with, information systems of other Federal agencies and the civilian scientific and technical community will be sought.⁵

The proposed center, therefore, would constitute a step toward an integrated plan for the development of a national technical-information network

aimed at improving the dissemination and exchange of scientific and engineering work sponsored by the Government. In essence, it represents the logical extension and development of the ASTIA facility which exists today.

In a tentative way the following represents a general description of how such a facility might be structured and equipped using the methodology available within today's state of the art.

⁵ DOD Sets 2 New Programs for Technical Data Handling, *Electronic News*, January 12, 1963.

Basic Assumptions

Certain basic assumptions must be made about the nature, volume, and sources of the literature involved in a typical center of the future. Government contracts normally specify that the contractor will furnish progress and final reports for work undertaken with federal funds. These reports vary in form, but they generally appear as nearprint documents containing textual and graphic information. There is little or no standardization imposed by the government, hence there is wide variance in the color, style, type, and format of the material. The number of copies printed is variable, dissemination procedures are erratic, and the Government has no inviolate collection.

Automation, if it is to begin anywhere, must generally begin at the source. In consequence, the Government in its contractual negotiations would need to amend its regulations to insure several very basic ingredients for the electronic information centers.

Source Data Standards

The first is that the contractor's report should be prepared in a type-font suitable for automatic reading by a character-recognition machine, or that with each printed document there would be included a machine-language by-product capturing the basic data in digital form. The second is that the contractor should be required to transmit his report, as soon as it is prepared, in digital code over communication links to the center. The third stipulation is that every document should be photo-reduced to microfilm specifications set by the Government and that the master negative should be sent to the electronic information center. A fourth requirement would call for the preparation of a title page containing an abstract; the elements of information on this page would be rigidly controlled according to prescribed format specifications. Finally, the contractor would have to agree to assign a unique number, provided by the Government, to the report. In essence, the Government would thus have established machine-language and micrographic standards at the source of report generation.

By setting the standards and decentralizing the workload, the electronic information center could receive report information as soon as it is prepared. This, at times, might be before it was actually

**Immediate
Processing**

printed, inasmuch as machine language would be available before copy went to the printer. Thus, the center would have the informa-

tion as soon as it is generated, and in a form that permits processing with a minimum of human intervention. If the center can process the data early and quickly, then it goes without saying that the data would be available for use by researchers almost without delay. Machine language at the source and concomitant machine-processing guarantee the center freedom from processing arrears.

The center, given machine language as specified, would undertake the following operations, automatically using equipment available today:

**Automatic
Catalog**

Establish an automated catalog. Master records containing bibliographic citation and an abstract could be automatically filed into a very large random-access memory. The large memory would be associated with a computer which would load the data into the file and then automatically create subordinate files by author, title, date, security classification, etc.

**Automatic
Dissemination**

Establish automatic dissemination. Since the entire text of the reports would be subjected to a computer program for automatic indexing, the same program could simultaneously watch for new information that coincided with the interest "profile" of a specific researcher or contractor. A subordinate subject file would be created automatically from this process, and printed accession lists tailored to the researcher's specific requirements would be sent to him.

**Remote
Inquiry
Stations**

Establish input/output communication links. An inquiry station could be located at several research- and government-library locations throughout the country. Requests for information by title, author, or subject could be satisfied by either receiving a typewriter-like message or a visual display of the full contents of an abstract on a cathode ray screen. If a specific request resulted in a long bibliography or a special list, the data would be transmitted over slower communication lines to be received in digital code suitable for print out on line printers, electric typewriters, EAM tabulators, high speed printers, etc.

**Automatic
Printing**

Establish an automatic printing capability. With data stored in digital form, it will be possible to automatically instruct electronic photocomposition machines to prepare high-quality printing material for publication of catalogs, cards, bibliographies, indexes, special lists, etc.

The center, given a microform of the report as specified earlier, could undertake the following operations, automatically, using equipment available today:

**Electronic
Graphic
Store**

Establish an automatic graphic storage file. Inasmuch as each report carries its own unique number, the interfiling of report material in microfilm form can be facilitated. Any number of devices,

(Walnut, Filesearch, Lodestar, etc.) exist for the establishment of such a file. Using xerographic printers, report duplicates in hard copy could be prepared locally. Or, with facsimile, it would be possible to scan the basic report in the center and have it reproduced miles away at a remote regional location. It could also be scanned with video and reviewed on a TV monitor elsewhere. Finally, it could be duplicated on file in its microform and forwarded to the user that way. In any event, the integrity of the basic file would remain intact, and the electronic information center would become a duplicating rather than a circulating library.

Because almost all of the data preparation would be done at the source and the use of hard copy would be de-emphasized, the kind of center described above could be housed in fairly small quarters. Space would be needed for the computer and associated equipment, for some communication gear, for the microphoto store, and for a local inquiry reference station.

A more detailed list of support equipment would include:

1. Medium-size digital computer
 - a. Large input/output capacity
 - b. Random-access digital store
 - c. Large-bulk storage capacity
 - d. Supervisory printers
 - e. Supervisory volatile-display devices
 - f. Large graphic random-access store
 - g. Magnetic tape, paper tape, and card readers
 - h. Computer to print equipment
2. Large-volume photocopy and photocomposition equipment
3. Standard offset presses and duplication devices
4. Facsimile devices
5. Microphotographic storage systems
6. Film and photo viewers
7. Teletype and telephone communication equipment
8. Audio devices
9. Special test equipment
10. Automatic character or mark-sense readers

While the preparation of the original text material would be done on a decentralized basis at the source, the processing of the data for cataloging, dissemination, etc., would be performed centrally.

Thus only the central installation would have a large capital-investment requirement for equipment. The outlying network stations would require only modest installations for their service input and output needs.

The one element of the plan which makes the entire proposition practical and realistic is the control which the sponsor, in this instance the Government, could exert over the standards for source-data preparation. This control is essential. With it come all of the advantages of rapid communications and ease of machine handling. Without it, we would seriously question the value, economy, or usefulness of any machine application to the over-all information system.

The machine methodology and information-processing techniques described above are feasible and attainable within today's engineering environment. Almost all of the equipment involved represent shelf items currently in manufacture. What is new in the concept is the interaction of users with a distantly located store of information. This is the crucial, underlying element of all network concepts and it is an area where we desperately need some practical experience.

The hypothetical center described above can be viewed as an extension of the ASTIA facilities that exist for handling Department of Defense technical reports. Today, DOD contractors forward their reports to ASTIA for central processing. This results in the creation of tools for automatic catalog searching, hard-copy reproduction, and the provision of other documentation services to authorized customers. The fundamental differences between today's structure and that which is suggested for tomorrow are the requirements for standardiza-

tion and communication. Standardization (putting information into machine-readable format at the source of data preparation and establishing micro-filming standards) will permit decentralized processing in a form which is compatible with the needs of a central facility. Communication will provide the means for reducing over-all processing and servicing time by allowing faithful, rapid transmission of digital information between the center and its contractors and between the center and its users. Figure 11 depicts the flow of data, processing activity, and user interactions with an advanced type of ASTIA facility.

Continuing to use this center as an example, it is possible to postulate further how such a facility might find itself a partner in a much larger information network. The "new ASTIA" could then be considered as one important node in a major technical information and communication network; one, perhaps, that might be devoted to the dissemination of scientific and technical information throughout the United States. (It is assumed that a national communications system will evolve irrespective of the pressures that may develop for information networks.)

Figure 12 shows a suggested national technical-information and communication network that contains six regional centers. To permit maximum service to users, the regional centers are located in or near densely populated areas, their precise locations being greatly influenced by the presence of local research libraries and the needs of government and industry.

For example, the Eastern Regional Center might be located in or near Washington, D.C. This center could serve users in the eastern region through such local centers as ASTIA, the National Agricultural Library, the National Medical Library, the Library of Congress, the Patent Office Library, NASA, AEC, etc. In addition to being an independent regional center, it is likely that this center would also serve as a national center—having gen-

eral administrative responsibility for the entire national technical-information and communication network and for communication contacts with other countries.

In a similar way, the other regional centers would support local centers, which are major sources of information in their respective areas.

The main objective of the total network would be to provide a uniform processing and communication system for printed information in prescribed scientific and technical fields. It would provide guidance for the standardization of input, establish indexing standards, and provide the communication means by which member centers of the network would have immediate access to the resources of the network as a whole.

It is envisaged that processing will be accomplished centrally and that reference tools will be selectively created to meet the special needs of the regional centers. Communications will extend from each regional center to all sources and users of information in that area. Universities, libraries, industry, and government contractors will qualify as users. Individual scientific researchers will thus have access to the unclassified resources of the regional centers through any number of local centers. Electronic safeguards will be built into the network so that classified resources can be made available on a "need-to-know" basis. The over-all communication network will be capable of handling multiple requests without delay.

The operating guide lines of the proposed network are critical. It is not possible for a family of regional centers to survive in an undisciplined environment. The requirements of standardization will probably be emphasized the most at the source of data preparation and within the technical communication field. Beyond that, the system should be organized so as to provide the user with wide latitude and sufficient flexibility in levying and pursuing his information needs.

PROPOSED NETWORK OF CENTERS

An interconnected network of national information centers will have access to each other's resources through a national communication system. Regional centers will in turn serve numerous local

information centers through local communication systems. Regional centers will be responsive to the information needs of thousands of local centers. Local information centers will become the nerve cen-

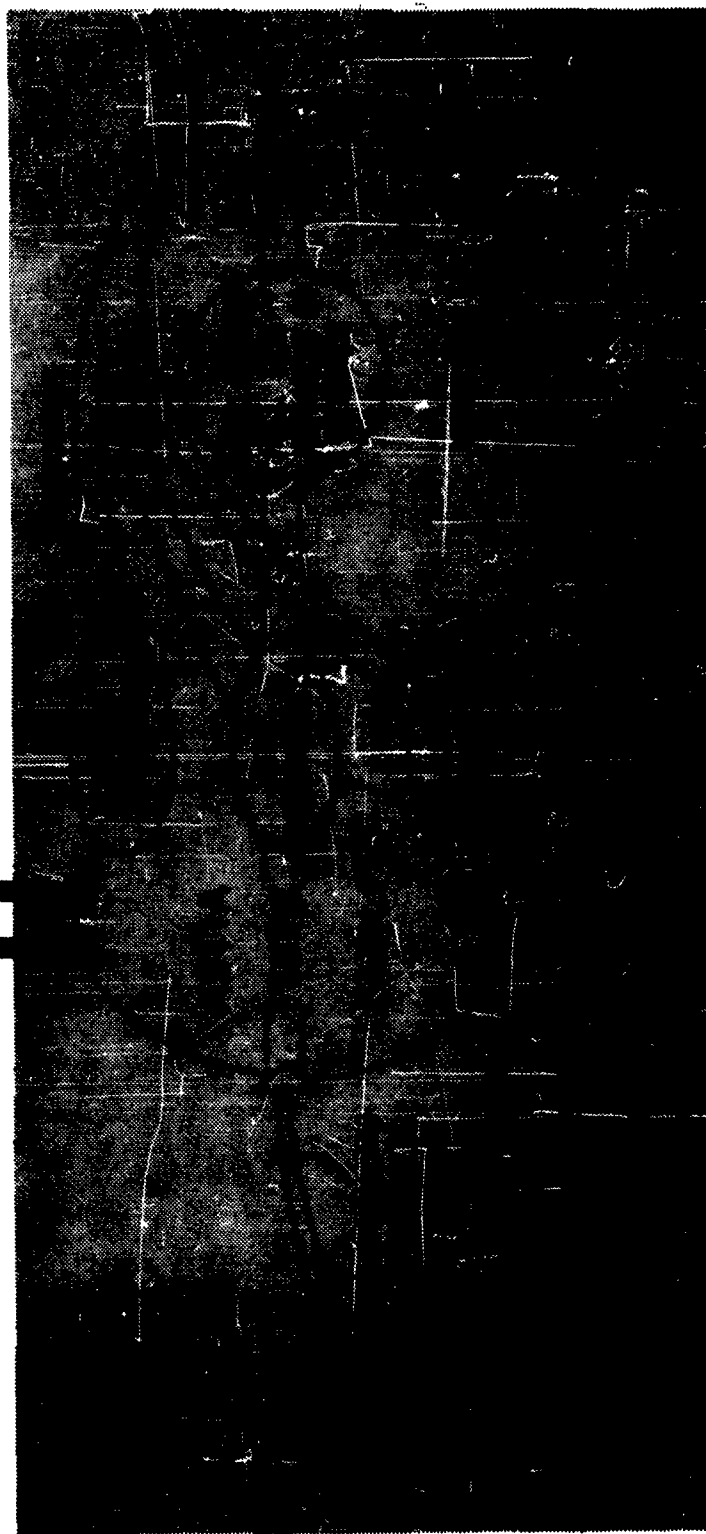


FIGURE 11. FLOW OF DATA TO AND FROM A TYPICAL CENTER

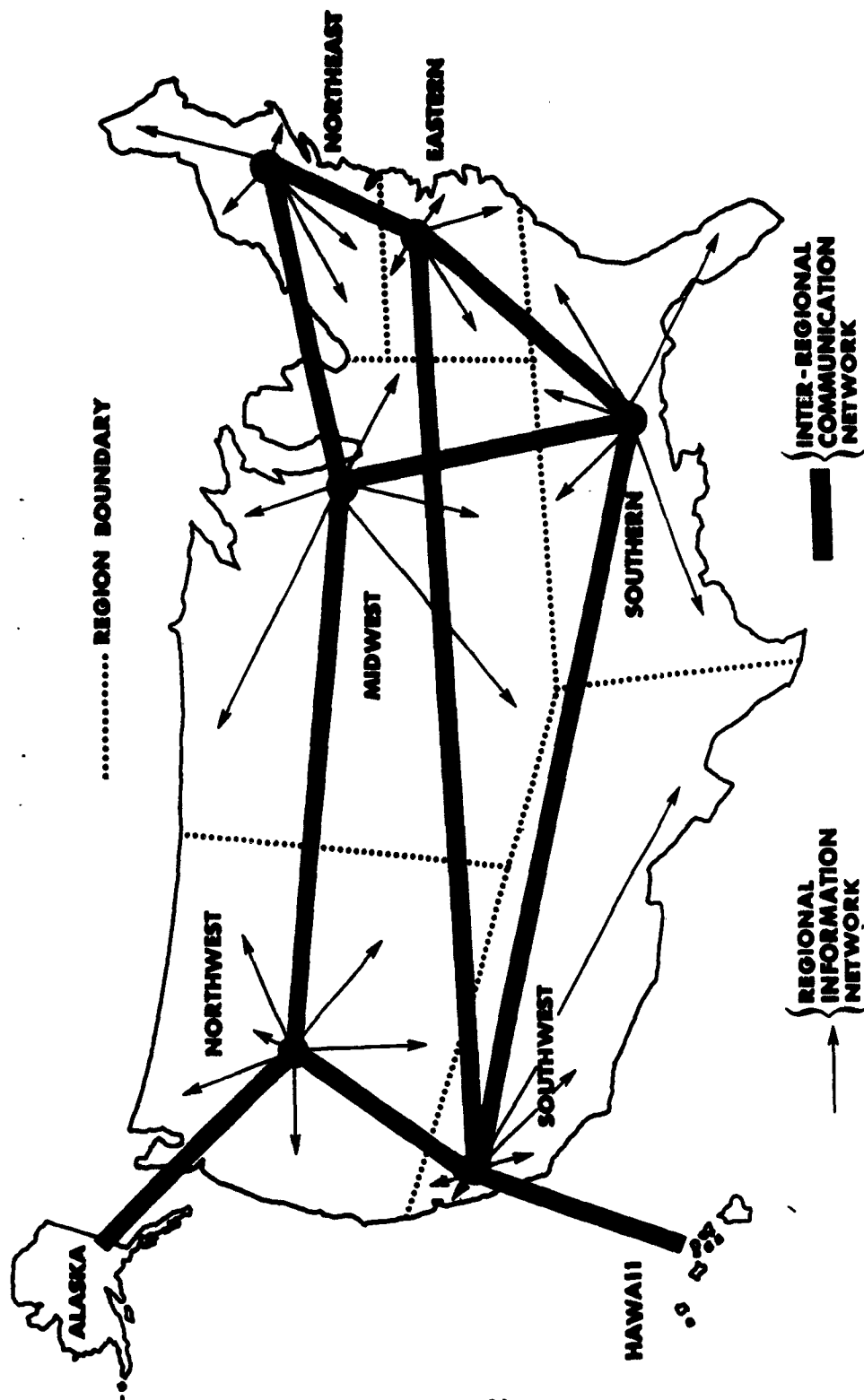


FIGURE 12
NATIONAL TECHNICAL INFORMATION AND COMMUNICATION NETWORK

ters of the communities of the future; an intimate relationship will exist between the home and the resources of the local center and between the center and local government contractors and research establishments.

The national, regional, and local information centers will exist to enrich our lives and thought by utilizing technology to increase the availability of books and information services and to strengthen and support our national research efforts and programs. The typical library of the future will be part of this network of centers intimately tied in with all facets of man's activities. Assumptions regarding the network structure and the number of centers are dependent upon switching and communication capacities and population density, rather than upon the quantity or quality of available information. In other words, the structure and complexity of the information centers will depend on rates of use, rather than on the characteristics of the information.

Moreover, we conjecture that future information centers at the local level will include facilities for information storage, collation, and dissemination, with direct communication links to each customer installation in the area of its responsibility, and to each research and government facility. People will undoubtedly continue to find it desirable to visit their local centers in person, but they also will be benefactors of expanded services at their office desks, such as those they now receive by telephone.

NETWORK CHARACTERISTICS

The pattern of information resources for this network system is unique. For example, local centers will store and handle information and services which use-patterns indicate are most frequently desired by the people in their areas of responsibility, just as do present-day libraries. Regional centers will not duplicate these resources or services; they will store information and provide services which use-patterns indicate are only infrequently desired within their larger areas of responsibility. National centers will be designed as single, centralized compendiums of information and service resources capable of satisfying every known requirement of their users.

In general, this system should produce very high

Today, many libraries provide specialized services for a fee; the information service of tomorrow might provide certain services on a rental basis for those who need them and are willing to pay for them. This might require the installation of special communications equipment in private homes and in government offices. The anticipated availability of cheap nuclear power should increase the feasibility of such installations.

It is hoped that each local center will reflect the information needs of its customers, and, consequently, that these centers will achieve the greatest level of functional uniqueness in the entire system. It is unlikely that local centers will be capable of responding to every request they receive. When a local center cannot handle a request, it will contact its appropriate regional center which will either respond on the basis of its own information resources or will contact another region.

The purposes of the regional center will be to service the local centers, to optimize the value of inter-regional center communication and cooperation, to integrate new media into the historical environment of printed materials, to operate the facilities in support of individual and governmental information requirements, and to provide a dynamic physical setting for learning, self-education, and research. Continental or national centers will communicate with each other and with their own subordinate centers.

accuracy and reliability figures, as well as convenience figures, which should be constructed and applied. Response times should *approximate* microseconds to seconds for demand requests, and where pre-scheduled single or continuing information requests exist, the network should be capable of handling them in their entirety in terms of presentation at the desired time and complexity of presentation.

Automatic and instantaneous translation from unfamiliar languages is an indispensable prerequisite to this system. Data-storage capacities will have to exceed what now would be considered fantastic, but the ALA anticipates that normal advances in computer technology will serve to increase the size

of computer stores over the next decade. However, it is doubtful that equipment techniques alone can increase storage capacity to accommodate the information that will be needed a decade hence. Consequently, there undoubtedly will be greater and greater standardization of computer input and output language and an equally apparent trend toward language compression via symbology—a shorthand of symbols which will permit super-compacted expression of the information being communicated. Computer-language standardization and compression will complement expected increases in the storage capacities of equipment and permit a more efficient form of information registration in the equipment's memory, thereby reducing the number of bits necessary to express meaning in the store. By the time this has been accomplished, the ALA presumes that users will have learned to use the language of the system and that contact between the system and its users will be efficient.

The computer core of the center will be general-purpose equipment; this will be surrounded by language processors and special-purpose analog equipment which will transduce the digital output of the core to a communicable meaning for input into a communication channel. Equipment programs will be of various types. Dictionary and compiler types of computer programs will be the responsibility of the center. A specific request for information or services will in fact constitute communication of that which is desired and also the instructions as to how to get it.

This brings us to customer installations at home or at the desks of government researchers. Ideally they would be multi-channel affairs. They would involve input/output channels for audio, video, image reproduction, text reproduction, and the possibility of any combination thereof. The equipment supporting these media also would possess filters capable of indicating whether a request represents a logical possibility, thereby reducing operational noise in the center. This means that local centers must be able to re-program customer installations, and these installations must possess some memory

capacity of their own capable of being exercised by the local center. In effect, the home-memory system should be composed of two elements: one controlled from the center, and one controlled by the user; one on input/output, the other on output/input.

The switching complexities involved in a system of this magnitude are obviously beyond the present state of the art. But given advances of the type registered during the past several decades, it should be possible in the future.

The regional and local information centers will equally serve the entire population—farmers, lawyers, teachers, doctors, businessmen, students, housewives, and skilled and non-skilled laborers. The entire complex will be capable of handling either requests for spot information or the delivery of an entire literary volume. For the most part, all requests will be accepted simultaneously with the assistance of large-capacity, real-time computers. The response to these requests will be staggered according to priority, length of reply, and availability of the material.

The size of the center will necessitate some subsidization by local, state, and federal organizations. The local centers will be supported by local subscription, the regional by state and federal subscription, and the national networks by federal subsidy. All routine inquiries will be handled without charge. Reproduction requests will necessarily be subjected to a materials cost.

The greatest effect of the information network of the future will be on the staff itself. Inasmuch as these people will be its voice, their knowledge and training will greatly influence the general public. In addition to the classical requirements of librarianship, the staff of each center will need to have a broad liberal and scientific education in information-retrieval theory and practice, knowledge of machines and systems, and the relationship of the human to the machine. The ultimate worth of the library of the future will rest largely—as in the past—on the capabilities of the people who operate it.

III. COMPENDIUM OF TECHNOLOGY

CURRENT TECHNIQUES AND EQUIPMENT

When discussing some of the more futuristic technological implications for libraries, it is pertinent to describe first the pattern of equipment development as it exists today, as well as the research underway that will lead to future development.

Over the past five to ten years, U.S. manufacturers have been attempting to develop new equipment to fill recognized or anticipated library needs. In some instances this commercial activity has centered on satisfying the needs of one specific information system, but in most cases the effort has taken the direction of simply trying to find new markets for existing products. As a result, available equipment is highly specialized and covers only narrow segments of application and interest.

In the following material, various processes and equipment will be described, mainly to indicate the level of their development and to highlight their potential application to libraries or electronic information centers. No attempt will be made either to justify cost or to evaluate performance. Items have been selected to illustrate areas of work; therefore, they do not represent a comprehensive inventory of the great variety of experimental efforts underway in the field. The purpose of including them in this report is to convey to the Air Force the current state of information technology in order to provide insight into possible developments that can be expected tomorrow.

Office Duplicating Machines

Photocopying

Machine Language Electric Typewriters

Photocomposition Machines

Punched Card Equipment

The basic need to prepare catalog cards has intensified librarians' interest in the near-print methods of reproduction. Office duplicating machines which employ spirit processes—manuscript, offset, and xerography—have either been modified or adapted to satisfy short-run requirements for catalog cards in libraries.

Photocopying, however, is the primary and predominant method of reproduction in library service. It is thoroughly reliable in speedily providing users with copies of unique materials held in the collection.

Photocopying methods are accepted as a profitable substitute for many conventional manual library routines. The great advantage of photocopying lies in its service capability; in some cases it is more economical to provide "take away" copy service, in film or hard-copy form, than it is to circulate file material to users.

The Photoclerk is, perhaps, the best known and most widely used example of the direct copying method found in library operations.

Some libraries are beginning to use machine-language electric typewriters, like the Flexowriter, to produce catalog cards and to prepare lists of bibliographic material for printing. If some of a library's source data can be captured in machine language (e.g., when preparing bibliographies, subject heading lists, etc.), photocomposition machines can then be used to prepare final copy for printing in the type font and style required for a given publication.

There are a number of devices for producing photo offset plates directly from lines printed on individual punched cards or from punched paper tapes. Other automatic equipment permits photographing single or multiple lines from the text imprint. Thus, by combining the flexibility of punched cards with a compatible print-

High-speed Output Printers

Character Recognition Machines

Auditory Recognition Machines

ing capability, the mass reproduction of information from a library-data file becomes feasible. Increased speed and a variety of edited output formats results when computers are linked up with suitable output printing equipment. This is especially true when computer output drives electronic photocomposition machines to create offset plates in any mixture of type font, size, and style.

Line printers are commercially available as peripheral output equipment which is normally sold with standard data-processing machines. However, while line printers are very useful in business-data processing, they do not yet possess the printing flexibility required for library publications. Generally speaking, standard output equipment prints one line at a time in a prescribed type font and style. Its type font usually consists of all capital letters, and its speed ranges from 100 to 1,000 lines (120 characters per line) per minute. Some output printers use styli to create individual letter characters from combinations of dot patterns. Others employ cathode ray tubes that are capable of generating alphanumeric characters at very high speed—up to 5,000 lines per minute.

The ability to automatically convert original data from the printed page to machine language is basic to the use of high-speed data-processing machines in information work. Until this is possible, librarians will not be able to convert existing manual files to a form suitable for machine processing. In the absence of automatic conversion equipment, it is necessary either to type or keypunch the data over again. Both processes are notoriously expensive, slow and liable to produce errors. For these reasons engineers undoubtedly will continue their efforts to produce a device which will automatically scan the letters, words, and sentences of a text, converting them directly into discrete digital representations. The ultimate engineering goal is to rapidly "read" large quantities of printed information so that further processing of the data can be performed by a computer.

Today, only alphanumeric data in a prescribed type font is readable by machine. However, data stored in libraries and information centers represent many alphabets printed in varying type styles and with intermixed fonts. The two most popular character-recognition techniques currently in use involve either optical scanning or magnetic ink reading. Neither, in its present form, can be used as a general-purpose character-recognition system for examining a typical page of printed text.

Research in auditory recognition is being done to determine if a machine can discriminate phonetic sounds automatically and, in so doing, produce a satisfactory digital code for machine input.

A number of experiments have been conducted, and corresponding computer programs have been written, having to do with the possibility of using computers for quasi-intellectual processes. The force behind this experimentation results from an appreciation of the power of combining three basic characteristics of the general-

**Computers and
Electronic
Data
Processing**

**Information
Retrieval**

**Central
Computer
Services**

**Electronic
Sorting,
Collating,
and
Searching**

**Mechanical
Translation**

**Automatic
Indexing
and
Abstracting**

**Searching
Natural Text
by Computer**

Micro-photography

Microfilm

purpose computers: (1) its extremely high speed; (2) its stored program which allows it to perform a pre-specified order of elementary operations; and (3) its capability for automatically changing its program. Thus, there has been considerable speculation and much research to find out if the general-purpose digital computer can be harnessed to perform tasks in the field of information retrieval, as well as to serve as a substitute for many of the burdensome routines associated with standard library operations.

A library need not buy a digital computer to obtain the advantages of automatic data-processing systems. Central computer services are available throughout the country. These can be used to a limited extent, depending upon the type of machine in use and the availability of program time on that machine.

During the early 1950's, computers were used increasingly for numerical computation. In consequence, computer programmers wrote more and more subroutines suitable for handling a broad class of complex mathematical functions. Later, as equivalent experience was gained with computers in business-data processing, a whole new class of programs was written for handling and processing combined numerical and non-numerical data. This work provided computer capability for sorting, collating, and searching great quantities of data; for controlling input and output devices; and for developing printed bibliographies and lists in a great variety of formats. Within the past few years, emphasis has been placed on machine analysis of the syntax and semantics of natural language. This has led to the development of computer programs for language-data processing, machine translation, automatic indexing, automatic abstracting, etc. Still other computer programs have been written for preparing permuted title indexes as well as conventional printed indexes.

Several researchers have produced computer programs which embody sophisticated mathematical principles for searching natural language text after it exists in machine-readable form. Research work has explored ways of extracting meaning from text by means of word association, syntactical analysis, and even contextual analysis. Advanced mathematical notions such as the calculus of probability and the theory of relevance have also been applied.

Although computer technology has been applied to library work chiefly in indexing and searching, attempts are being made to determine if electronic data-processing machines can support more conventional library operations, such as serial-record maintenance, circulation control, financial management, etc.

Professional and informational personnel also are giving special attention to microphotography and facsimile transmission. The former provides a tried and proven method for densely packing printed information into compact form; the latter holds the promise of improved interlibrary communications.

Microfilm, at present, is the most effective means of controlling file growth. An impressive array of different cameras and a mul-

Aperture Cards
Microfiche
Microcards

Diazo

Kalvar

Photochromics

Film
Viewers
Copy
Printers

Reflex
Copying
Machines

High-Speed
Xerography
Automatic
Binding

Facsimile
Transmission

Audio
Communication

Wirephoto

Flying
Spot
Scanners

tiplicity of microfilm media are available commercially. Roll film, aperture cards, film in cartridges, microfiche, sheet film, and microcards are but a few of the examples of common microforms presently in use in information installations.

New dry processes have been introduced to overcome the disadvantages of wet chemical development which is normally associated with the silver-halide film process. Diazo, for example, is a film which is exposed with ultraviolet light and developed in gaseous ammonia. Kalvar, another film, is exposed with ultraviolet light, but is developed with heat at a temperature equivalent to that of a warm iron. The latest dry process is photochromics. This process claims data-compression ratios of up to 400:1 with practically no loss of resolution. Photochromic film is exposed with ultraviolet light and can be erased with white light if required.

Printed material which is compressed into a microform calls for auxiliary equipment—inspection viewers, service viewers, and printing equipment for individual page copying. Equipment available on the market makes it possible to view any microform and obtain, if needed, a copy of all or part of a page in a matter of seconds. Devices that fall into this category provide push-button copying, frame-by-frame, using manual, semi-automatic, or fully automatic auxiliary means. In most libraries, reflex copying equipment, such as the Photostat machine, is still the production mainstay for copying printed material. By using high-speed xerographic printers and automatic binding equipment, page enlargements of the microform can be assembled as a conventional book.

Ever since RCA conducted a demonstration of Ultrafax at the Library of Congress in the early 1950's, the library profession has been actively interested in the possibility of using facsimile transmission as a medium for conveying printed information from one library to another. The perfection of facsimile transmission has important implications for libraries and information centers. It offers the promise of being able to make unique library materials speedily available to interested users who are at locations remote from the only source of supply. In essence, it would provide a visual data-transmission technique to supplement audio communication by telephone. Facsimile transmission is not a new technique. It has been known for many years, but has had limited use because of the slow technical development of data-transmission facilities and associated equipment.

Newspaper wirephoto services are the popular form of graphic transmission. In wirephoto, a relatively successful method, the photo recorder produces a light-sensitive film which then must be developed and processed like any other photo. In direct facsimile, however, the material is set on a drum and scanned by a flying spot. Based on the spot reflections of the text imprint, electrical impulses are generated which are sent over wires or microwave links to a recorder synchronized at the receiving end. Electro-sensitive paper is used for recording, and the product is essentially an instantaneous

**Video
Transmission**

**Closed
Circuit
Television**

**Remote
Catalog
Search**

**TV
Compatible
Display**

**Flat
Display
Television**

**Electronic
Film
Searching**

**Electronic
Searching
Machine (Film)**

Machines

**Rapid
Selector**

form of graphic communication.

Video recording and transmission also provides a visual form of graphic communication over great distances. Although the present technology satisfies the requirements of long-distance documentary transmission, development of such video equipment has been retarded because manufacturers do not yet see a market for it. Experiments, however, in closed-circuit television between libraries have been conducted to learn more about the implications of such a relationship.

Regardless of method, it is clear that advances are needed in the field of interlibrary communication and data transmission. Provision of such service will make possible the timely sharing of information resources among several information centers, thus reducing the necessity to keep duplicate holdings in libraries.

Aside from the equipment available for long-distance communication of the printed page, prototype devices have been built for the purpose of performing card-catalog searches and file inspection from a remote location. These electro-mechanical devices provide access to a prescribed segment of a card catalog; and, by using a television camera, the data on selected cards are scanned for transmission to a remote viewing station.

Standard cathode ray tube-display systems use specially designed tubes or standard tubes with special circuitry to display alphanumeric and symbolic characters. These are used for recalling and displaying general memory information from a computer store to a requester in English-language format. A recent development provides a character generator and display system which is compatible with home-TV receivers. This system converts digital data into a tabular display of alphanumeric characters on one or more television receivers.

For a number of years the Army-Navy Instrumentation Program has maintained a requirement for a flat, transparent display tube. Much effort has gone into producing these displays for air navigation, air traffic control, and general memory display. Recently, a new approach using ferroelectric-electroluminescent panels shows promise of meeting this requirement. Experimental panels have proven the feasibility of flat display panels, but have not yet been developed to the level of TV resolution.

Of particular interest to librarians and documentalists are the principles of electronic film searching which, on the surface, have seemed to satisfy the basic requirements for dense storage, fast access, and flexible display of information.

Ever since Dr. Vannevar Bush proposed a Memex machine in 1946, there has been a rush of equipment designed to combine the dense-storage capability of film with the searching speed of electronics. The Rapid Selector was the first such device to be built. It recorded frames of abstracts and corresponding digital codes on a 2,000-foot reel of 35 mm film. Despite certain engineering weaknesses, the machine was put into trial operation in a library environment—the U.S. Department of Agriculture Library—and served to

**Minicard
Media
Flip
Filesearch
Lodestar
Verac
Walnut**

**Multicolored
Film
Stores**

**Language
Laboratories**

**Teaching
Machines**

**Sight
and
Sound
Machines**

**Book
Charging
Machines**

stimulate information people to think more seriously about the application of the concept. A later model of the Rapid Selector, built by the Bureau of the Census, is in operation today in the Navy's Bureau of Ships.

Following the Rapid Selector, other equipment appeared, including: Minicard, Media, Flip, Filesearch, Lodestar, Verac, and Walnut. Originally, each of these devices was designed to satisfy the objectives of highly specialized information-system customers, but all of them represent technical progress in the stride toward combined use of electronic and photographic media for many purposes.

Minicard and Media are systems which store digital and graphic information on chips of film. Flip, Filesearch, and Lodestar, on the other hand, require that the stored information be contained in sequence on reels of film. Verac and Walnut are slightly different. The former requires a store of glass plates on which a matrix of images is recorded; the latter uses strips of Diazo film for recording. Both, like the others, provide electronic-searching capabilities.

None of the techniques mentioned above were designed to be suitable for book storage, and, in applying them, most attention has been focused on recording articles in technical journals or in special multi-page reports. Since each technique is basically photographic, storage is not limited to printed text only—all forms of graphic material are susceptible to the same treatment.

Most digital computer-searched film stores use black-and-white film with very high resolution capabilities, but with limited density levels. The U.S. Air Force is now using a color film cartographic technique which can be scanned and measured to 500 levels of tone discrimination. This capability raises the possibility of increasing the versatility of material stored in automatic data-processing systems.

Recently the Hammarkjold Library at the U.N. announced the inclusion of a language laboratory in its physical plant. With the progress being made in programmed language instruction, a wide variety of special-purpose equipment will be finding its way into other libraries as well. This auxiliary equipment will be essential if librarians are to make optimum use of the newer media that are becoming companions to the books on library shelves. Teaching machines, random access slide projectors sound sight and machines, kinescope viewers, stereophonic sound machines, record players, closed-circuit television, etc., are examples of modern equipment that is needed to fully utilize data that may be stored in libraries on film, in wax, or on magnetic tape.

The largest number of near-transactions in a library occur in the circulation department. Therefore, the profession has paid special attention to finding ways and means to automate this statistical, clerical operation. After many years, the book-charging machine was developed—a device which is used more widely, actively, and profitably than any other in the nation's library network. Many types and models are manufactured by several commercial companies. The

book-charging machine represents library use of the "management by exception" principle so common today in most supply and inventory applications in business-data processing.

From the above review of machine research-and-development activities that are of pertinent interest to libraries and information centers, three specific research-and-development-objectives emerge: to achieve more compact storage of the source material, to rapidly provide intellectual and physical access to it; and to display it or provide it in a form suitable for individual use. Microphotography, the application of computers, the use of facsimile and video techniques, photocopying, etc., represent different bands in the spectrum of development effort underway to achieve these objectives.

At the 1951 Windsor Lectures on Bibliography in the Twentieth Century, the late Dr. Louis Ridenour

remarked that libraries would undergo many radical changes in the near future that would transform them into a "communications center of a sort." The capsule review of the technological groundswell sketched above, plus the description of a still brighter technological horizon ahead (as given in the next section) both serve to emphasize the validity of Dr. Ridenour's prediction. With the introduction of new media for recording knowledge and the impact of technology on our current systems of graphic communication, it is conceivable that in time librarians will evolve into dynamic electronic information centers.

FUTURE TECHNIQUES AND EQUIPMENT

One word symbolizes the difference between the library of today and the information center of tomorrow—availability. The full potential of the vast collections of man's recorded knowledge will be fully realized when data-processing technology makes available to the user specifics regarding the kind, quantity, and location of existing information. Future storage and retrieval equipment will provide an inviolate library in which any and all material will always be available. Advanced com-

munications technology will transmit the desired information to the user at his convenience, whenever he is and whenever he wants it.

Let us consider the present rapid technological evolution upon which the library of the future might be predicated. The following devices, now being developed in laboratories across the nation, will play a key role in the achievement of tomorrow's information center.

Integrated Electronics

Molecular structure, quasi-standardized, multi-element electronic circuits manufactured by processes of growth, printing, evaporation, or other physical-chemical means will be used throughout the library of the future. Computers, data processors, and decoders will be composed of many such modules, of a few basic types, which lend themselves to a minimal size and number of interconnections.

"Thin Film" Techniques

The rapid growth of solid-state electronics since the development of this relatively new field of physics has led to studies of "thin film" techniques, wherein materials exhibit useful properties when used sparingly in layers measure in wave lengths of light. Little understood at present, such techniques can be predicted to give rise to complex computers which are derived from the evaporation of an infinitesimal amount of moderately expensive material onto a substrate of cheap and abundant material. Example: compounds of sulphides (cadmium, zinc, etc.) in layers a few angstroms thick, on

Coherent Light

substrates of glass or ceramics, may, in a space of a few hundred square inches of surface, compose a completely intraconnected and interconnected computer arithmetic unit capable of functioning at gigacycle-per-second rates.

Coherent electromagnetic radiation will be used for the transmission of information via propagation through free space, as well as over closed circuits. Complex integrated electronic circuits will be interconnected by coherent light coupling; thus, proper juxtaposition of molecular circuits will accomplish electrical signal coupling and transmission between modules via "lightpipes" or free space. Conventional wiring as it is known in the Twentieth Century will be largely eliminated, and conversion of optical energy to electrical-signal format and back again will take place in the integrated electronic modules without recourse to copper path wiring.

Optical Masers

Optical masers (or lasers—light amplification through stimulated emission or radiation) will be, for the library of the future, an optical transmission line repeater-amplifier, a modulated searchlight or equivalent line-of-sight transmitter, a display device (an online projector), and an oscillator for a "million telephone calls."

Intercontinental Transmission

Communication satellites will serve as active repeaters or passive reflectors for intercontinental transmission of intelligence via modulated light-wave lengths. Coupled with optical wave guides over land masses (glass fibers a few microns in diameter will be the analog of metallic wire transmission lines), the cost of transmission of "intelligence" x the user "volume" will remain constant or nearly so; i.e., the expense of transmitting a recently published French novel from a Paris library to a requester's home in Terre Haute, Indiana, will be approximately the same as if that book were on sale in a Terre Haute bookstore.

Bionic Logic

Neuron-like or adaptive logic will be utilized to implement such functions as character recognition for language translation, information storage (insertion), and screening of retrieval requests for suitability criteria. Such a technique will further minimize computer-encoder size and allow for growth capability to help defeat system obsolescence. Thus, information-center machines will interpret user requirements and suitability in a "learning" process. Indeed, centralization of certain types of documentation will be fluidly transitory in nature as the machines "learn" to anticipate regional needs and build up specialized inventories of information based on previous experience.

Digital Coding

Sophisticated and adaptive coding will be used not only in computers, data processors, and the like, but also in communications, display (aural and visual), and reproduction facilities. Utilization of digital techniques throughout the library of the future will result in a number of benefits.

1. Adaptability to secure cryptography for governmental, industrial, and private subscribers.
2. Increasing the base of standardization for minimizing obsolescence of equipment.

3. Minimizing costs through standardization of components.
4. Increasing efficiency of communications through reduction of error probability due to noise and interference.
5. Increasing efficiency of communications through elimination of data redundancy.

Analog Signals

Analog signals from video devices may be quantized, coded, and transmitted in this digital (or binary) form. Subsequent demodulation, decoding, and resynthesis will allow for high-quality transmission of graphic material. Printed symbology (letters, books, documents), printed data (maps, charts, etc.), as well as graphics of purer art forms (paintings, photographs, etc.) will be transformed into machine language enabling storage, transmission encryption, reproduction, and general data processing.

Video Displays

Primary display requirements will be fulfilled by video displays of the reflective type in which the source of light is external to the display equipment (room lighting or display "edge" or flood-lighting) and only the reflectivity of elements in the display are modulated to present visual data. Such displays may vary in size from a small screen (perhaps 10 inches width/height) through intermediate multi-receiver screens (21-30 inches width/height) to a large screen (4-40 feet) for audiences of greater numbers.

Reflective and Solid-State Displays

The displays themselves, especially those in homes or business organizations will be of the flat or wall type, perhaps remote from their video-processing equipment. The reflective display will offer the attractive advantage of high brightness and contrast in normally well-lighted areas, with no loss of detail or quality, and will alternatively allow for viewing under dim or dark ambient lighting conditions by use of external artificial light.

Display of Pictorial Information

The display of pictorial information over the visible color spectrum will be achieved by external lighting in suitable combinations of two or more primary colors in conjunction with address of elements in the display with appropriate color signals. By manual or forced (automatic) selection the display will be either dynamic scene information (flicker-free moving pictures) or be capable of long-term storage for tabular or graphic information of a temporally static nature. Multiple overlay displays will be implemented by electronic or optical signal mixing for technical personnel desiring orientation of information for purposes of comparison and measurement.

Reflective Panel Display Implementation

The reflective panel display will be achieved by use of photochemical, electrokinetic, or other physical principles which are capable of varying the reflectivity of elements of a mosaic of certain materials by stimulating them with light (pencil beam) or electrical energy. Projection of modulated and scanning optical masers on certain dye materials, or electromagnetic or electrostatic orientation of microscopic mechanical elements (vanes, spheres, etc.), are two techniques which may be used to implement the reflective display.

Whether large or small, such displays will be of a modular nature in that they may be assembled from standardized components.

Display Operating Techniques

They will not require complex addressing mechanisms, but will operate similar to present-day television systems requiring only a modulating signal which may contain synchronizing information from the source.

Such panels may display graphic or symbolic visual data re-composed from quantized and coded master copy or scene information; or, conversely, the visual data may be wholly synthesized by a computer from data-processor stores and transformed to "readable" information. They will be formed largely from processed structural materials, such as aluminum, metal alloys, etc., to form small durable elements which operate electro-mechanically (e.g., electrostatic field orientation of a vane; electrostatic field attraction of a spring), or will be micro-encapsulated dyes whose reflectivity can be reversibly varied by light excitation (e.g., opto-chemical elements). In either case materials will be inexpensive and easily formed.

Luminous Solid-State Displays

Solid-state displays of the luminous type will be utilized where reflective displays are deemed undesirable. Electroluminescent panels of the mosaic or matrix type will be utilized in conjunction with other solid-state materials (photoconductors, ferroelectrics, etc.) for addressing and switching to display real or synthetic data. Brightness, contrast, and resolution will be equal to or better than that achieved with present-day television kinescopes.

Fabrication of Solid-State Displays

Fabrication of solid-state displays will be much akin to that of integrated electronic devices. Thus, production facilities may be somewhat standardized to produce devices similar in physical characteristics but widely divergent in their systems behavior.

Recording Media

For the purposes of this report, recording media are defined in three categories:

1. For archival storage and call-up.
2. For interim storage where "erasure" and re-use of the media is desired (as in a home or a business-terminal facility).
3. For duplication for personal study and use, either in public service areas of the information centers or at user terminals

Advanced Recording Technology

Archival storage in the information center will be of high-packing density, such as may be afforded by electrostatic recording on highly stable thermoplastic reel or cartridge film, or will utilize dielectric tape bases of synthetic materials similar to mylar which may carry magnetic oxides.

Dynamic-Access Stores

It is anticipated that such stores will be of a dynamic-access nature similar to tape loops and disk files, whereby start-stop inertia is eliminated and access time is reduced by keeping stores in a continual cycling process. This also enables multiple but sequential access for readout. Related techniques of air-bearing surfaces will be generally employed to reduce wear and replacement problems. Readout techniques will employ low-inertia scanning by light beam (photoelectric sampling) to further reduce contact-wear problems.

Interim Store-Recording Techniques

Interim store-recording techniques may be of the electromagnetic or electrostatic type where rapid "writing" is facilitated and no processing is required. Erasure is possible once the information either

Duplication Recording Media

has been duplicated or assimilated and is no longer required by the user. Such devices may take the general form of magnetic tape recorders in use today, but with considerably less expensive integrated electronics which will be tied into local communication links to satellite centers. Such interim storage-recording media may be used for "soft copy" display on reflective or electroluminescent panels or "hard-copy" printers for permanent duplication.

Duplication recording media will most likely utilize either real or synthetic paper for electrostatic, electrophotographic recording from interim tape storage or on-line recording from the information center. The latent electrostatic images may be formed by exposure to electric charging elements; or with photosensitive layers, exposure to optical images. Development of the latent image will be achieved by chemically inert powders, either dry or in liquid suspension (e.g., carbon black in resin binders or dyes suspended in a solvent) so that permanence may be achieved by heat treatment or evaporation.

Direct- Contact Printing

Such techniques may utilize extremely low-cost plasticized paper on a continuous web for direct-contact printing via a single-line scanning, cathode ray device (incorporating thin optical window or fiber optic window and phosphor) and dry-process development of the image. All of the elements involved will be extremely cheap; the cost of materials involved in printout of a 500-page book will be no more than the present cost of the ink and paper usually involved.

Cutting and Stacking

Incorporation of cutting, collation, stacking, and binding of the resultant "book" may be envisioned, or more likely, simple cutting and stacking will result in a sort of manuscript format which the user may easily have bound or stapled, either mechanically or by a quick-heat, paper-edge fusing process. Alternatively, the electrostatic interim storage-recording media, of appropriate format, may be erased or fixed in the manner latterly described.

Printers, as described above, will be capable of speeds exceeding 100,000 characters per second for text, or approximately one 500-page book in ten seconds, plus perhaps an equal time for development, fixing, and cutting. Such a book would average 60 symbols or characters per line, 40 lines per page, on a 5x8 inch format.

Techniques will be implemented by many new devices, primarily of solid-state nature.

Masers or lasers will be in widespread use in communications, display, and recording.

Optical Masers

Communications lasers will be utilized as extremely wide-band, modulated oscillators for coherent and simultaneous radiation transmission of as many as a million narrow-band messages (three kilocycles per second). Band-width conservation will be a thing of the past in utilizing wave lengths in the infrared and ultraviolet spectrum. Lasers also will be utilized as repeaters in parametric amplifier arrangements for long-haul transmission links through space or over land.

As a communications transmitter, the high-power laser will be

Uses of Glass Fibers

Fiber Optics

Light-wave Length, Coherent Transmission

Solid-State Devices

capable of line-of-sight transmission, regardless of atmospheric conditions, by proper selection of a carrier wave length with penetrating characteristics.

In display, lasers of lower power levels will provide "writing" light beams for reflective or phosphorescent screen systems. Light valve and scanning techniques presently emerging will enable on-line projection of laser beams in the visible (or invisible) spectrum for direct viewing or secondary excitation of phosphor screens.

Glass fibers will be utilized, not only in cathode ray devices, but also as:

- (1) optical wave guides for transmission of modulated coherent (laser) radiation over land hauls;
- (2) "wires" coupling opto-electronic logic elements in computer complexes;
- (3) encoder-decoder devices for coded message processing or transmission; and
- (4) transmission screens for display purposes.

In conjunction with lasers, glass fibers offer a controlled environment for transmission of intelligence and will ultimately replace or complement metallic transmission lines of the open wire, coaxial cable, and wave-guide types.

The high-temperature ductility of glass will allow inexpensive manufacture in continuous lengths suitable for long "lines" similar to present telephone open-wire systems. Ten thousand fiber diameters on the order of tens to hundreds of microns each, with each fiber supporting multiplexed transmission of millions of messages, may be bundled together to form a single cable no more than 1 centimeter in diameter. "Insulation" in the form of glass "cladding" minimizes crosstalk and reduces losses.

Light-wave length, coherent transmission enables the use of glass transmission lines, which are far less costly than copper path lines, both in material costs and in the number of messages per "wire." Optical computer techniques, coupled with bionic logic and integrated circuits, will utilize glass-fiber bundles for interconnections and electro-optical decoding at sub-computer speeds by use of electroluminescent-photoconductive elements. The use of fiber optics in spatially coherent and incoherent bundles for image geometry transformation, "scrambling," and electro-optical printing will be widespread.

In addition to the integrated circuits which have been described, solid-state devices will become basic components repeated in the equipment circuitry throughout the library of the future:

1. Electroluminescent phosphorus, capable of emitting when subjected to direct voltage (non-alternating) fields, may be driven directly from computer output circuits.
2. Photoconductive crystals and other photosensitive cells, in molecular bond with electroluminescent devices, will form opto-electronic logic elements for decoding to displays as well as the light-emitting displays themselves.

Long-Range Communications

Communications Satellites

Cycling Relay Satellites

Active Repeaters

3. Ferroelectric crystals will be used to address and switch electroluminescent-photo-conductive displays at higher speeds; crystals will be grown, in a constrained fashion, to any shape, or formed by other physical-chemical means.

4. Thin-film devices will perform as active circuit elements analogous to vacuum tubes, transistors, etc., as well as passive elements such as resistors, capacitors, and inductors.

5. Cryogenic techniques will enable small specialized components for use as inductors, memory elements, etc.

No discussion of the technologies pertinent to the library of tomorrow would be complete without consideration of the role of long-range, global communications. Intercontinental, intra-continental, and local links will compose the library of the future's circulatory system through which its life-blood will flow. The predication of specialized national libraries, regional information centers, and remote subscribers implies a continual and heavy flow of communication traffic. Inquiries may be of narrow-band nature, while return response may require wide-band, higher-volume channels to reduce delays.

In 1960, 3,700,000 transoceanic telephone messages were sent over the trans-Atlantic submarine cable. It is predicted that 20 years hence this number will increase to 100,000,000. Authorities in the field of communications believe this is an exponential increase in message volume which cannot be met except by orbital communications space satellites. Add to this the prediction that in 100 years message volume may be hundreds of billions, and it becomes obvious that the communications spectrum must open up into the light-wave lengths to accommodate the multiplexing of millions of messages on a single carrier wave, in addition to the use of line-of-sight vehicles.

There will be two types of relay satellites: active repeaters and passive repeaters. Active repeaters will contain receiver-transmitter equipment and be powered by solar-thermionic or nuclear-turbopropulsive energy sources for indefinite life. (It may even be possible for manned maintenance space vehicles to periodically service satellites, resulting in the eventual use of cheaper power sources.) In general, this type of relay station will contain wide-band circuitry and switching equipment and may be of the low-altitude (3,000-10,000 miles) cycling type, or of the synchronous 24-hour type.

Cycling relay satellites, since they pass over given terrestrial regions, will contain "handover" circuitry so that messages may be transmitted through a series of such relay satellites until one is over the appropriate terminal. Code format of the message correlated with latitude-longitude "bookkeeping" systems will direct the messages to the proper terminal.

Synchronous relay stations, manned or unmanned, will be active, and because they will be in an equatorial orbit at an altitude of 22,300 miles, will remain stationary and permit coverage of a plus or minus 81 deg. latitude and, circumferentially, almost one half of the earth's surface. Three such stations will permit communications

**Altitude
Stabilization**

**Passive
Repeaters**

**Message-Unit
Costs**

**Message
Unit
Defined**

between most of the populated areas of the world, while the synchronous satellites will provide communications to now uncivilized regions (e.g., the poles) which may become highly developed in 100 years.

These satellites will be altitude-stabilized to permit use of highly directional antennas, thereby reducing required transmitter power.

Passive repeaters will be low-altitude satellites for short-range (less than 1,500 miles) narrow-band data transmission. Since no active devices will be aboard, these passive repeaters will take the form of reflectors, which may be omni-directional or quasi-directional. Metal-coated spheres, dipoles, etc., may make up such devices.

The passive repeater may be used for short-term (a few minutes) transmission of messages of an inquiry nature between not-too-distant regional information centers. Thus, properly abbreviated and coded messages could help to reduce required transmitter power and transmission time. Return transmission of the desired information may be over the wide-band circuits of the active relay satellites or synchronous station.

In order to estimate, on a message-rate basis, the cost to the user of such a system of space communications, some rather far-fetched calculations and many assumptions must be made. The cost of about nine rather short-lived vehicles for the Ranger satellite program (of deep space and lunar probes) was approximately \$200 million. It has been estimated that a single 6-megacycle-circuit space satellite might be built for between \$50-100 million.

Without assuming too much about the status of costs in the future, one can predict that a system of synchronous and cycling-type communications satellites might cost several billion dollars, including all the earth-based support equipment and development required, but *not* including all terminal facilities, since these will be dictated by growth of user-demands and regional development.

If the modest figure of ten billion data-phone message units per year is assumed, one can see that ten cents per message unit would be a reasonable upper limit of cost which would amortize the cost of the communications system, defray operating expense, and allow some margin of profit for commercial operation. One might define a message unit quite arbitrarily as equivalent to a three-minute telephone call over a 3-kilocycle band-width circuit (where greater utilization is made of the band width), resulting in say, 2,500 bits per second data rate.

This gives a figure of 180 seconds x 2,500 bits per second, or a little under 500,000 bits. As an example, a coded single page of text might consist of perhaps 25,000 bits, so that 20 pages might be transmitted for the cost of a single message unit. Thus, a 500-page book would cost about \$2.50 to transmit, terminal to terminal. A painting would require high fidelity, and a coded transmission of a color portrait might require 10,000,000 bits to describe it and cost \$2.00 to transmit. Of course, these costs would vary depending upon the speed of transmission required, special cryptography, etc., and would

**"Narrow-Banded
Graphic
Communications"**

**The
Home
Library**

**Electrostatic
Contact
Printing**

not include other processing charges such as research, retrieval, display, or printing.

It is obvious from the above that lower costs are predicted for the communications of the future. This prediction is largely based on the expected increased volume of traffic and the lower cost of the systems involved.

One of the many keys to the reduction of cost of communications, especially of visual data, will be a technique we might call "Narrow-banded graphic communications." This technique will provide a closer approach to non-redundant information transmission by utilizing coding, spatial predictors, filters), and optical correlation. The following examples illustrate the point.

For transmission of text, it is obvious that electrical codes of a digital nature can reduce the information band-width channel (or time) of transmission required. Further reductions can be accomplished by utilization of non-ergodic symbology, such as shorthand, standardization of language, and language compression in order to reduce language redundancy itself.

Pictorial data offers a greater challenge to efficient transmission. Here spatial redundancy plays a great part and may be overcome by optical analysis.

A graphic analyzer composed of television-type camera tubes or solid-state opto-electronic sensors might scan copy at a high rate in a wide-band closed circuit. Ancillary computer circuits will measure the number of optical (video) transitions on an element-by-element basis. Neuron-like or adaptive logic will then adjust an encoder for optimum code format, as well as program the transmitter scanning device to "skip" areas where no information is present (blank spaces between lines of text, lines on maps or charts, etc.) or where no change of data has occurred.

Thus a page of text, a map, photo, slide, or painting may be imaged onto a scanner for an instant to "adapt" the logic circuits; then transmission over narrow-band circuits may proceed, optimally coding the video data from the scanning pick-up device which will ignore areas where no information exists. Automatic graphic analysis and narrow-band coding and transmission will largely be employed in the electronic information centers as a means to further reduce the cost of communications media.

The home library will contain a wall-hung television display of the reflective or electroluminescent type, which may be used both for "live" entertainment and information as cathode ray tube displays are used now. In addition, other sub-systems, such as tape recorders, audio equipment, etc., will be available in somewhat the same setting as in today's high-fidelity audio-visual grouping.

An additional unit might be a high-speed printer incorporating a fiber-optics face-plate cathode ray tube for direct electrostatic contact printing on a six-inch web of photosensitive paper (paper cost: approximately 100 mills per linear foot) developed and fixed by powder toner or merely by a heating element. This unit would also

**"Programmer"
Unit**

**Home
Dataphone**

**Catalog
Search
Through
Home
Dialing**

incorporate a character forming generator so that an ordinary or special text might be obtained in a manner similar to that in which one might order a typewriter keyboard; maps, graphs, and pictorial data may be obtained by switching out the character generator.

Such a device would be an accessory to the wall display which would contain most of the necessary circuitry for synchronizing, scanning, and modulating the printer.

Tape recorders of electrostatic or magnetic nature would be wide-band for facilitating playback of "live" television signals, as well as audio through the wall display.

A "programmer" unit will be central to the entertainment-library grouping which will include manual selection, but primarily will provide decoding and control of the home sub-systems via the telephone communications system.

All voice communications by telephone will be transcribed to digital code so that each home will have a dataphone or digital sub-set. By proper coding, an incoming call from a library information center (in response to a request) will be decoded by the programmer to activate the equipment in the audio-visual grouping. Requests may be made by telephone orally, by handwritten message image onto a video pick up device on the phone, or by the typewriter-like keyboard of the telephone itself. In any case, speech and video will be digitally coded at the home, transmitted, and then received and decoded at the center, where speech or video-recognition circuits will process the data.

Response to requests for catalog search or bibliography might be automatically dialed into the home and, through control of the programmer, displayed on the wall display (over a wide-band circuit), recorded on tape at slow rates for later home playback on the wall display over wide-band closed circuit, or printed onto paper for more permanent use and storage. The programmer will contain limited-memory or buffering circuits in addition to its coding, switching, and control circuits.

This home library would be linked to all of the great information centers of the world via appropriate communications. Certainly this concept rounds out the keynote of "availability."

Best Available Copy

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